

Memorandum

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Subject: Reregistration Eligibility Document for Disulfoton (D237134)

Attached to this memorandum is the revised EFED RED chapter for disulfoton. EFED has reviewed the public comments and has modified the chapter in response to the comments. This transmittal memo summarizes EFED's findings and recommendations for potential mitigation, monitoring and labeling.

The risk assessment was performed by evaluating use information listed in both the BEAD LUIS report for disulfoton as well as information supplied by Bayer Corporation, the major registrant for disulfoton products, and current labels (EPA Reg. No. 3125-172; 3125-307).

Background

Disulfoton is an organophosphate insecticide/acaricide used on a variety of terrestrial food crops, terrestrial feed crops, and terrestrial nonfood crops. Disulfoton is formulated as 15% granules, 8% emulsifiable systemic, 95% cotton seed treatment, systemic granules (1, 2, 5, 10%), and 68% concentrate for formulating garden products. Directions regarding application intervals, number of applications and total application per year or crop cycle are not always specified by the label.

Environmental Fate Summary

Parent disulfoton has low to intermediate potential mobility (K_{oc} s 386-888) and is neither persistent (average (half-life) $T_{1/2}$ is 4.8 days) nor volatile. Disulfoton photo-degrades within 2.4 days on soil and in water under natural sunlight the $T_{1/2}$ is 4 days. Disulfoton is essentially stable to hydrolysis at 20°C at pH 5, 7, and 9, but hydrolyzes much more rapidly at 40°C. Soil applied disulfoton will be degraded rapidly oxidized by chemical reaction and microbial metabolism to its corresponding D. sulfoxide and D. sulfone. Aerobic soil metabolism data indicated that the sulfoxide ($T_{1/2}$ >17days) and sulfone ($T_{1/2}$ >120 days) degradates of disulfoton are more persistent and mobile than parent disulfoton. In a recently submitted leaching study, nine additional metabolism products were identified, at least three may have human toxicity issues. Field dissipation information also indicates that the degradates may persist longer in the environment, D. sulfoxide has a half-life of 8 to 10 weeks and D. sulfone remained fairly stable over a 294-day period. There is insufficient environmental fate information on the degradates to fully characterize their fate and transport. The half-life for total disulfoton residues was greater than 170 days. Open literature suggests that D. sulfoxide can be reduced back to disulfoton. Information is not available to assess the significance of the reduction of D. sulfoxide. Aerobic and anaerobic aquatic metabolism studies which could provide valid model inputs for the degradates disulfoton sulfone and disulfoton sulfoxide have not been submitted. Although the registrant provided the Agency with additional information concerning the fate of disulfoton residues in water under controlled artificial conditions (MRID 43568501 and LaCorte et al., 1995), this information is limited and should not be used for model inputs. Specifically, these studies provide information concerning the combined effects of hydrolysis, photolysis, and metabolism, with photodegradation contributing significantly to the dissipation.

Water Resources Summary

The Water Resources Assessment considered the potential of disulfoton and its degradates, D. sulfoxide and D. sulfone, to contaminate ground water, surface water, and drinking water from labeled uses. The assessment included a TIER II (PRZM/EXAMS) analysis which estimates environmental concentrations (EECs) in surface water for disulfoton parent and for total disulfoton residues, TDR (sum of disulfoton, sulfoxide, and sulfone), applied at the maximum label rate and number of applications to barley, cotton, potatoes, spring wheat, and tobacco. The OPP standard farm pond was used for ecological exposure assessment and the Index Reservoir and Percent Crop Area (PCA) were factored into the drinking water assessment. These crops represent major uses and generally reflect the highest use rates and total amounts. The potential for disulfoton parent residues (and TDR) to contaminate ground water was assessed using the EFED ground-water concentration screening model (SCI-GROW) and monitoring data available in EFED's Pesticides in Ground Water Data Base (PGWDB), EPA's STORET data base, and in the USGS National Water Quality Assessment Program (NAWQA). Surface-water monitoring data sources available in the USGS NAWQA program and the EPA's STORET data base were also considered.

Disulfoton is likely to be found in runoff water and sediment from treated and cultivated fields.

The fate of disulfoton and its degradates once in surface water and sediments, and the likely concentrations therein, cannot be modeled with a high degree of certainty since data are not available for the aerobic and anaerobic aquatic degradation rates. Estimates of disulfoton concentrations in ground water did not consider the anaerobic soil metabolism, as studies have been submitted by the registrant, but have not reviewed by EFED. The anaerobic soil metabolism rate for disulfoton appears to be slower than the aerobic soil metabolism rate. For this assessment, the aerobic aquatic metabolism rate, required by EXAMS, was estimated by using EFED's recommended guidance to estimate an aerobic aquatic metabolism rate from aerobic soil metabolism rates (e.g., multiply the soil aerobic metabolism rate used in PRZM by 0.5 (doubles the half-life)). In lieu of actual data on persistence of disulfoton in an aquatic environment, the assumed aquatic metabolism rate for EXAMS will reduce the estimated concentrations, but not the uncertainty. Considering the relatively rapid rate of microbial degradation in the soil and aquatic photolysis in surface water, parent disulfoton may degrade fairly rapidly, whereas the degradates are more persistent and may not degrade as rapidly in water. As noted above the registrant has submitted additional information suggesting a fairly rapid degradation of disulfoton and D. sulfoxide and D. sulfone in natural water under artificial conditions.

Sorption data (reflection of mobility, e.g., K_{ds}) are also not available for the sulfoxide and sulfone degradates (and other degradates), were considered to be equal to the parent in the modeling. Typically, however, the D. sulfoxide and D. sulfone degradates are more mobile than the parent. The peak concentrations of parent disulfoton appear capable of being quite high, especially when high, foliar application rates are used and coincide with a rainfall event. Limited monitoring confirms this (VA, CO). A large degree of latitude available in the disulfoton labels also allows for wide variation in possible application rates, total amounts of disulfoton applied, application methods, and intervals between applications. Lower application rates would result in lower estimated concentrations (EECs). Additionally, considerable uncertainty exists because the percent crop area or PCA value was not known, thus, the default value was applied.

The low concentrations typically reported in available ground water and surface water monitoring data of parent disulfoton tends to confirm fairly rapid degradation and low mobility, but do not preclude potentially high peak values (few reported high values). Although no assessment can be made for degradates due to lack of data, limited data suggests that the degradates are more persistent than disulfoton, suggesting their presence in water for a longer period of time than the parent

Surface Water Modeling:

In the Tier II PRZM/EXAMS assessment, the overall estimate of the multiple year mean concentrations of disulfoton in a farm pond over multiple years simulated ranged from 0.21 µg/L for two applications at the maximum rate (1.00 lb ai/A) to barley in Virginia to 1.14 µg/L for potatoes in Maine with three applications at the maximum application rate (1.00 lb ai/A). Maximum, or peak, estimated concentrations of 26.75 µg/L occurred for one 4.00 lb. ai/ac application of disulfoton to tobacco. For the other scenarios, the maximum concentrations ranged from 7.14 to 18.46 µg/L.

The estimated drinking water concentrations using the Index Reservoir (IR) and PCA (PCA) concepts for the same scenarios were evaluated. The long term mean of the parent disulfoton concentration in the Index Reservoir and by PCA ranged from 0.23 to 1.31 µg/L for cotton and tobacco, respectively. The 1-in-10 year estimated annual mean concentration ranged from 0.43 to 2.77 µg/L for cotton and tobacco, respectively. The peak 1-in-10 year estimated drinking water concentration for parent disulfoton ranged from 7.13 to 44.20 µg/L.

The Tier II modeling results from PRZM/EXAMS fall within the range of concentrations for surface water reported in the STORET database (0.0 to 100 µg/L, 96 percent of 8137 samples were reported as less than 16 µg/L), a Virginia monitoring study (0.37 to 6.11 µg/L) and NAWQA (0.010 to 0.060 µg/L). But because some of the data in STORET have a high degree of uncertainty because many samples were only listed as “actual value is known to less than given value”, the maximum concentration of samples was not always known (see Appendix III). The modeled concentration estimates are generally greater than those seen in the monitoring data. The modeling results therefore cannot be confirmed by the monitoring data.

Because the degradates of disulfoton (including oxygen analogs): sulfoxide and sulfone are also toxic, the EECs of the total disulfoton residue (TDR) in a farm pond was also considered. The overall estimated of the multiple year mean concentrations of TDR in a farm pond over multiple years simulated ranged from 3.89 µg/L for two applications at the maximum rate (1.00 lb ai/A) to barley in Virginia to 9.32 µg/L for tobacco in Georgia with one application at the maximum application rate (4.00 lb ai/A). Maximum, or peak, estimated TDR concentrations of 58.47 µg/L occurred for one 4.00 lb. ai/ac application of disulfoton to tobacco. For the other scenarios, the maximum TDR concentrations ranged from 15.32 to 52.93 µg/L. There are no monitoring data to evaluate these concentration estimates from PRZM/EXAMS modeling.

Total disulfoton residues using the IR and PC concepts were also considered for drinking water. The long term mean of the total disulfoton residues (TDR) in the Index Reservoir and by PCA ranged from 2.55 to 10.42 µg/L for cotton and potatoes, respectively. The 1-in-10 year estimated annual mean TDR concentrations in the IR ranged from 5.10 to 16.72 µg/L for cotton and potatoes, respectively. The peak 1-in-10 year estimated TDR concentrations in the IR ranged from 20.83 to 104.92 µg/L. There are no monitoring data to evaluate these concentration estimates from PRZM/EXAMS modeling.

Uncertainty surrounds these estimates because the sites selected for modeling represent sites though to be representative of vulnerable sites. Additionally, the IR was generic (to each scenario) and data to fully understand of the fate of disulfoton and disulfoton residues is available. Evidence suggests that the concentrations will not be as high as suggest by the modeled estimates. The PCA values have been estimated by OPP for spring wheat (0.56) and cotton (0.20). The default for value for all agricultural land of 0.87 was used for the barley, potatoes, and tobacco scenarios. Better estimates of the PCA for these crops would reduce the uncertainty associated with the estimated drinking water concentrations.

Ground Water Modeling:

The maximum disulfoton concentration predicted in ground water by the SCI-GROW model (using the maximum rate 4 lb. a.i./ac and 2 applications - potatoes) was 0.05 µg/L. The maximum total disulfoton residue concentration predicted in ground water by the SCI-GROW model for the same scenario is 3.19 µg/L. The SCI-GROW model represents a "vulnerable site", but not necessarily the most vulnerable, treated (here) with the maximum rate and number of disulfoton applications, while assuming conservative environmental properties (90 percent upper confidence bound on the mean aerobic soil half-life and an average K_{oc} value). Monitoring data has reported a few disulfoton concentrations higher than those estimated by SCI-GROW.

Disulfoton Monitoring Data:

Based upon the fate properties of disulfoton parent, which is not very persistent, or mobile you would not expect to observe disulfoton in ground water. The Pesticides in Ground Water Data Base (USEPA, 1992) summarizes the results of a number of ground-water monitoring studies conducted which included disulfoton (and rarely the disulfoton degradates D. sulfone and D. sulfoxide). Monitoring, with no detections (limits of detections ranged from 0.01 to 6.0 µg/L), has occurred in the following states (number of wells): AL (10), CA (974), GA (76), HI (5), IN (161), ME (71), MS (120), MN (754), OK (1), OR (70), and TX (188). The range of detection limits, especially the high ones (e.g., 6 µg/L) reduce the certainty of these data. Disulfoton residues were detected in ground water in Virginia and Wisconsin. In Virginia, 6 of the 12 wells (8 monitoring wells) sampled monthly from June 1986 through December 1990 had disulfoton detections ranging from 0.04 to 2.87 µg/L. In Wisconsin, 14 of 26 wells (municipal, community, and home wells) sampled, during May and June 1982, had disulfoton residues ranging from 4.0 to 100.0 µg/L, with a mean of concentration of 38.4 µg/L. Although the Wisconsin study has received some criticism, particularly over QA/QC issues, EFED believes that this study needs to be considered in the risk assessment. The Wisconsin study was conducted in the Central Sand Plain of Wisconsin which is extremely vulnerable to ground-water contamination. Detections of other pesticides in this area have often tended to be orders of magnitude greater than those seen other areas. One hundred twenty wells were analyzed in MS for disulfoton degradates sulfone and sulfoxide and 188 wells were analyzed in TX for sulfone. Limits of detection were 3.80 and 1.90 µg/L for the sulfone and sulfoxide degrade, respectively, in MS. There were no degradates reported in these samples. In a more recent ground-water monitoring study conducted in North Carolina, there were no detections of disulfoton, disulfoton sulfoxide, and disulfoton sulfone. Efforts were made in the study to place the wells in vulnerable areas where the pesticide use was known, so that the pesticide analyzed for would reflect the use history around the well. Limitations of the study include that sites were sampled only twice and the limits of detections were high (e.g., > 1.0 µg/L) for some of disulfoton analytes (NCIWG, 1997; DP Barcode 267486).

Surface-water samples were also collected (same Virginia study as noted above) in study to evaluate the effectiveness of Best Management Practices (BMP) in a Virginia watershed. Approximately half of the watershed is in agriculture and the other half is forested. Parent

disulfoton was detected in several surface-water samples with concentrations ranging from 0.037 to 6.11 µg/L. These levels are within the same order of magnitude of the estimated environmental concentrations (EECs) obtained from the PRZM/EXAMS models for parent disulfoton which range from 0.21 to 1.14 µg/L for annual mean daily concentrations and 7.14 to 26.75 µg/L for peak daily values.

Disulfoton residues have been detected in surface water at a low frequency in the USGS NAWQA study. The percentage of detections with disulfoton concentrations >0.01 µg/L for all samples, agricultural streams, urban streams were 0.27%, 0.20, and 0.61%, respectively. The corresponding maximum concentrations were 0.060, 0.035, and 0.037 µg/L. Disulfoton has not been detected in ground water in the NAWQA study. Although pesticide usage data is collected for the different NAWQA study units, the studies are not targeted, specifically for disulfoton.

Limitations for the monitoring studies include the use of different limits of detection between studies, lack of information concerning disulfoton use around sampling sites, and lack of data concerning the hydro geology of the study sites.

About 50 percent of the well samples reported in STORET had low levels (<1 µg/L) of disulfoton residues. However, there were indications of some high concentrations (the other 50% were reported as <250µg/L), which may be a reflection of how the data were reported as the disulfoton concentrations in the monitoring were not always known. This is because the detection limit was extremely high or not specified, and/or the limit of quantification was not stated or extremely high. Disulfoton concentrations were simply given as less than a value. Therefore, considerable uncertainty exists with respect to the STORET monitoring data. The spatial and temporal relationship between disulfoton use, rainfall/runoff events and the location and time of sampling frequently cannot be adequately determined.

Toxicity Summary

The available acute toxicity data on the TGAI indicate that disulfoton is: highly to very highly toxic to birds on an acute oral basis (LD_{50} = 3.2 to 39 mg/kg); moderately to highly toxic to birds on a dietary basis (LC_{50} = 333 to 622 ppm); very highly toxic to mammals on an acute oral basis (LD_{50} = 1.9 to 15 mg/kg); moderately toxic to bees (LD_{50} = 4.1 µg/bee); very highly toxic to moderately toxic to freshwater fish (LC_{50} = 39 to 7,200 ppb); very highly toxic to freshwater invertebrates (LC_{50} = 3.9 to 52 ppb); highly toxic to marine/estuarine fish (LC_{50} = 520 ppb) and very highly toxic to marine/estuarine invertebrates (LC_{50} or EC_{50} = 15 to 900 ppb). Acute toxicity for the sulfone degradate indicate that it is highly toxic to birds on an acute oral basis (LD_{50} = 18 mg/kg), moderately toxic to birds on a dietary basis (LC_{50} = 558 to 622 ppm), highly toxic to mammals on an acute oral basis (LD_{50} = 11.24 mg/kg), highly toxic to bees (LD_{50} = 0.96 µg/bee), highly to moderately toxic to freshwater fish (LC_{50} = 112 to >9,200 ppb), very highly toxic to freshwater invertebrates (LC_{50} = 35.2 ppb), and moderately toxic to marine/estuarine fish (LC_{50} = 1,060 ppb). The sulfoxide metabolite is very highly toxic to birds on an acute oral basis (LD_{50} = 9.2 mg/kg); moderately to highly toxic to birds on a dietary basis (LC_{50} = 456 to 823 ppm); moderately toxic

to bees ($LD_{50} = 1.11 \mu\text{g}/\text{bee}$); highly to slightly toxic to freshwater fish ($LC_{50} = 188$ to $60,300$ ppb); very highly toxic to freshwater invertebrates ($LC_{50} = 64$ ppb); and slightly toxic to marine/estuarine fish ($LC_{50} = 11,300$ ppb).

Chronic toxicity studies on disulfoton established the following NOAEC values: 37 ppm for birds, 0.8 ppm for small mammals, 220 ppb for freshwater fish (4.6 ppb for bluegill sunfish, using the factor of chronic to acute values for the rainbow trout), 0.037 ppb for freshwater invertebrates, 16.2 ppb for marine/estuarine fish early life-stage, 0.96 ppb for marine/estuarine fish for life-cycle, and 2.35 ppb for marine/estuarine invertebrates. There are chronic invertebrate studies on the 2 major degradates--sulfone (NOAEC 0.14 ppb) and sulfoxide (NOAEC 1.53 ppb).

Risk Assessment Summary

Risk Characterization

A. Characterization of the Fate and Transport of Disulfoton

I. Water Exposure

(a) Surface Water

Disulfoton is likely to be found in runoff water and sediment from treated and cultivated fields. However, the fate of disulfoton and its degradates once in surface water and sediments, and the likely concentrations therein, cannot be modeled with a high degree of certainty since data are not available for the aerobic and anaerobic aquatic degradation rates. Surface water concentrations of disulfoton and total disulfoton residues were estimated by using PRZM3 and EXAMS models using several different scenarios (barley, cotton, potato, tobacco, and spring wheat). The large degree of latitude available in the disulfoton labels also allows for a wide range of possible application rates, total amounts, application methods, and intervals between applications. Considering the relatively rapid rate of microbial degradation in the soil (<20 day aerobic soil metabolism half-life) and direct aquatic photolysis, disulfoton parent may degrade fairly rapidly in surface water. However, peak concentrations of disulfoton in the farm pond appear capable of being quite high, with 1-year-in 10 peak surface water concentrations of 7.14 to $26.75 \mu\text{g}/\text{L}$ and 90-day concentrations of 1.73 to $6.87 \mu\text{g}/\text{L}$ for the parent compound. The mean EECs of the annual means of disulfoton ranged from 0.21 to $1.14 \mu\text{g}/\text{L}$. Although there is a lack of some environmental fate data for the degradates, the assessment suggests that the degradates will reach higher concentrations than the parent because they are more persistent and probably more mobile. The estimated peak concentrations for the total disulfoton residues in the farm pond ranged from 15.43 to $58.48 \mu\text{g}/\text{L}$, 90 day average ranged from 12.20 to $35.30 \mu\text{g}/\text{L}$, and the mean of the annual means ranged from 3.89 to $9.32 \mu\text{g}/\text{L}$. Water samples collected at the site of a fish kill in Colorado contained D. sulfoxide at levels of 29.5 - $48.7 \mu\text{g}/\text{L}$, and D. sulfone at 0.0199 - $0.214 \mu\text{g}/\text{L}$. The aerobic soil metabolism studies show that the maximum sulfoxide residues are about 58 percent of total radioactive material, thus, the sulfoxide concentrations suggest that parent

disulfoton concentrations could range from 50.8 to 83.9 $\mu\text{g/L}$. The ratio of the disulfoton sulfoxide concentration to the average maximum disulfoton concentration was higher (74%) in the microcosm study (MRID # 4356501) than in the soil residues (58%).

The estimated drinking water concentrations (EDWC) for parent disulfoton and total disulfoton residues were also determined using the IR and PCA concepts. The peak concentrations of disulfoton in IR appear capable of being quite high, with 1-year-in 10 peak surface water concentrations of 7.13 to 44.20 $\mu\text{g/L}$ and annual mean concentrations of 0.43 to 2.77 $\mu\text{g/L}$ for the parent compound. The mean EECs of the annual means of disulfoton ranged from 0.23 to 1.31 $\mu\text{g/L}$. Although there is a lack of some environmental fate data for the degradates, the assessment suggests that the degradates will reach higher concentrations than the parent because they are more persistent and probably more mobile. The estimated 1-in-10 year peak concentrations for the total disulfoton residues in the IR ranged from 20.83 to 104.92 $\mu\text{g/L}$ and annual mean ranged from 5.10 to 16.25 $\mu\text{g/L}$, and the mean of the annual means ranged from 2.55 to 10.42 $\mu\text{g/L}$. These values will be highly effected by the value selected for PCA. The PCA values have been estimated by OPP for spring wheat (0.56) and cotton (0.20). The default for value for all agricultural land of 0.87 was used for the barley, potatoes, and tobacco scenarios. Better estimates of the PCA for these crops would reduce the uncertainty associated with the estimated drinking water concentrations.

Surface-water samples were collected in a study to evaluate the effectiveness of Best Management Practices (BMP) in a Virginia watershed. Approximately half of the watershed is in agriculture and the other half is forested. The detections of parent disulfoton in surface-water samples ranged from 0.037 to 6.11 $\mu\text{g/L}$ and fell within an order of magnitude with the estimated environmental concentrations (EECs) obtained from the PRZM/EXAMS models.

Surface-water monitoring by the USGS in the NAWQA (USGS, 1998) project found relatively few detections of disulfoton in surface water with a maximum concentration of 0.060 $\mu\text{g/L}$. As noted above disulfoton degradates were reported in surface water, when a rainfall event occurred following application to wheat, where fish kills occurred; pesticide residue concentrations ranged from 29.5 to 48.7 $\mu\text{g/L}$ for D. sulfoxide and 0.02 to 0.214 $\mu\text{g/L}$ (Incident Report No. I001167-001).

A search of the EPA's STORET (10/16/97) data base resulted in the identification of disulfoton residues at a number of locations. Often the values ranged from 0.01 to 100.0 $\mu\text{g/L}$ with most of the values reported as "actual value is less than this value." Thus, when a value of 100.00 $\mu\text{g/L}$ is reported, it is not known how much less than 100.0 $\mu\text{g/L}$ the actual value is known to be less. Thus there is considerable uncertainty surrounding some of the data in STORET.

(b) Ground Water

The SCI-GROW (Screening Concentration in Ground Water) screening model developed in EFED was used to estimate disulfoton concentrations in ground water (Barrett, 1997). SCI-GROW represents a "vulnerable site", but not necessarily the most vulnerable conditions, treated

(here) with the maximum rate and number of disulfoton applications, while assuming conservative environmental properties (90 percent upper confidence bound on the mean aerobic soil half-life of 6.12 days and an average K_{oc} value of 551 mL/g). The maximum disulfoton concentration predicted in ground water by the SCI-GROW model (using the maximum rate 4 lb. a.i./ac and 2 applications - potatoes) was 0.05 µg/L. The maximum total disulfoton residue concentration predicted in ground water by the SCI-GROW model for the same scenario is 3.19 µg/L (except 90 percent upper bound on mean half-life of total residues is 259.6 days).

Ground water monitoring data generally confirms fairly rapid degradation and low mobility, because of the relatively low levels and frequency of detections of parent disulfoton in ground water. There were no ground-water detections of parent disulfoton in the USGS NAWQA (USGS, 1998) with a limit of detections of 0.01 or 0.05 µg/L, depending upon method. . Most of the studies recorded in the PGWDB (USEPA, 1992) also reported no disulfoton detections. Disulfoton residues ranging from 0.04 to 100.00 µg/L were reported for studies conducted in Virginia (0.04 to 2.87 µg/L) and Wisconsin (4.00 to 100.00 µg/L). Of specific interest are areas where the concentrations of parent disulfoton reported in the studies (VA and WI) exceeded the estimate of 0.05 µg/L obtained from EFED's SCI-GROW (ground-water screening model) model. It should be noted that the Wisconsin data received some criticism which influences the certainty of these detections, no such criticisms or limitations exist for the Virginia study.

The major issues, concerning the Wisconsin study (Central Sands) were that the study may not have followed QA/QC on sampling and the failure of follow-up sampling to detect disulfoton residues in ground water as suggested by Holden (1986), have been considered by EFED in the ground-water quality assessment. The Central Sands of Wisconsin are known to be highly vulnerable to ground-water contamination. There are regions within the United States that have conditions that are highly vulnerable to ground water contamination and regularly have pesticides detected in ground water which far exceeds values seen elsewhere. Several of these areas are well documented, e.g., Long Island, Suffolk County, NY and Central Sands in WI. Although, some questions have been levied against the disulfoton detections in Wisconsin, the occurrence of disulfoton at the levels reported cannot be ruled out.

There were no detections of disulfoton, disulfoton sulfoxide, and disulfoton in the ground- water monitoring study conducted in North Carolina. Efforts were made to place the wells in vulnerable areas where the pesticide use was known, so that the pesticide analyzed for would reflect the use history around the well. Seven Christmas tree, one wheat, and two tobacco growing areas were sampled for disulfoton. Limitations of the study include that sites were sampled only twice and the limits of detections were high (e.g., > 1.0 µg/L) for some of disulfoton analytes. Uncertainties associated with the study include whether two samples from eight wells are adequate to represent the ground-water concentrations of disulfoton residues, did DRASTIC correctly identify a site's vulnerability, and were the wells placed down-gradient of the use areas.

The SCI-GROW model represents a "vulnerable site", but not necessarily the most vulnerable.

Several things should be considered. First, the Virginia and Wisconsin monitoring studies were probably conducted in areas vulnerable to ground-water contamination. The level of certainty with respect to vulnerability is probably greater for Wisconsin (relatively less uncertainty) than for Virginia (relatively more uncertainty). The occurrence of preferential flow and transport processes has been also noted in Wisconsin (and is also possible in Virginia) and may (speculation) have contributed to the "high" concentrations (especially in WI) when the initial sampling occurred, but not necessarily in the follow-up sampling). The knowledge concerning the disulfoton use in areas in association with the wells is not well known (high uncertainty). Some notable limitations of modeling and monitoring are presented elsewhere in this document

(c) Drinking Water

The Agency recommends that the 1-out-of-10-year peak values be used the acute surface drinking water level for parent disulfoton, and for chronic levels use either the 90-day and annual average. The maximum values are: 44.20, 2.77, and 1.31 µg/L or the peak, 90-day mean, and long term mean, respectively. For the total disulfoton residues the peak, 90-day mean, and long term mean are 104.92, 53.47, and 10.42 µg/L. The EDWCs for both parent disulfoton and TDR exceed the DWLOC values estimated by the Agency. The EDWCs values for the parent disulfoton have less uncertainty than the total residue, because there is more certainty surrounding the "estimated" aerobic aquatic metabolism half-life for the estimated aerobic aquatic half-life for the total disulfoton residues. It is recommended that the Virginia data be considered in the "quantitative" drinking water assessment for ground water exposure. The Wisconsin data should be noted and addressed more qualitatively. Highly vulnerable areas, such as the Central Sand Plain, do not represent the entire use area and can probably be better mitigated or managed a local or state level. Specifically, it is recommended that the 2.87 µg/L be used for acute and chronic exposure from ground water. Based upon the fate properties of disulfoton, the sulfoxide and sulfone degradates (more persistent and probably more mobile) have a greater probability of being found in ground water. It is likely that a ground water study (ies) may be required to better assess the potential exposure from the degradates (and also parent).

B. Characterization of risk to nontarget species from Disulfoton

Birds: Acute risk to birds is predicted especially for use patterns involving the 15 G formulation. All modeled application rates and methods for the 15 G formulation exceed the acute risk level of concern for birds, regardless of size. Robins were reported to have been killed following the application of a disulfoton granular product to a tree nursery. Carcasses were found during terrestrial field testing of disulfoton on potatoes, confirming the presumption of acute risk to birds. Since disulfoton is a systemic pesticide, the granular formulations can result in exposure through food items due to uptake by the plant tissues in addition to direct exposure to any unincorporated granules.

Foliar applications of liquid formulations present the greatest risk to herbivorous birds. Based on

the results of field studies, the residue levels on sampled invertebrates are well below those predicted by EFED's models, consequently insectivores did not appear to be at risk. However, there is field evidence suggesting that some species are extremely sensitive to disulfoton such that even low concentrations caused mortality. The Swainson's hawk kill appears to be the result of consuming grasshoppers. The hawks crop contents were analyzed and contained residues around 8 ppm. Finally, live blue jays collected 6 to 7 hrs after a pecan orchard was sprayed at 0.72 lbs ai/A had brain cholinesterase inhibition from 32 to 72% (White et al. 1990). Although it is unknown whether these birds would eventually die, Ludke et al. 1975 suggest that inhibition >50% in carcasses is evidence that death was caused by some chemical agent. Furthermore, it should be recognized that these birds were not only feeding on contaminated food, but also were impacted by dermal and inhalation exposure.

Ground applications of liquid formulations to soil, even at 4.0 lb ai/A would not be expected to cause mortality to birds. Field studies have demonstrated that residue concentration within food items -- vegetation, invertebrates and seeds -- in or on the edge of fields are well below those used in screening level assessments and empirically derived from aerial applications. However, in light of the points made in the previous paragraph, some mortality is possible given the possible multiple routes of exposure and hypersensitivity of some species.

Chronic risk to herbivorous birds are predicted from exposure to disulfoton when assuming birds are exposed to peak residues for a short period of time or average Fletcher maximum residues for longer periods. Based on reduced hatchling weight, the NOAEC is 37; both for bobwhite quail and mallard duck. Foliar applications and aerially applied soil sprays are estimated to result in 30 day average residues (based on maximum Fletcher values) on vegetation exceeding the avian chronic level of concern for application rates equal or greater than a single application of 1 lb ai/A. A residue monitoring study for Di-syston 8E in potatoes showed the peak residues on vegetation was 105 ppm after the initial application and 152 ppm following a second application 6 to 10 days later. In the same study, the means of the 3 applications for vegetation in and adjacent to fields were 41 and 14 ppm respectively. The upper bound 95% mean for the vegetation adjacent to the fields was 71 ppm. Therefore even empirically derived residues suggest that the chronic LOC is exceeded on foliage, but not invertebrates for a short time following aerial applications. It is anticipated that since the sulfone and sulfoxide degradates of disulfoton were similar in acute toxicity to parent disulfoton they would have similar chronic NOAECs. These degradates extend the time that total disulfoton residues are available for consumption. Since many of the applications of disulfoton occur in the spring, overlapping the breeding season for most bird species, there is the potential for significant reproductive impacts.

Mammals: Acute risk to mammals is expected for use patterns involving the 15 G formulation. All modeled application rates and methods exceed the acute risk level of concern for mammals, regardless of the mammals' size. Small mammal carcasses were found during terrestrial field testing of disulfoton on potatoes, confirming the presumption of acute risk to mammals. Since disulfoton is a systemic pesticide, the granular formulations can result in exposure through food items due to uptake by the plant tissues in addition to direct exposure to any unincorporated granules.

Applications of the liquid formulations especially by air can result in mammals being exposed to multiple routes of exposure --dermal, inhalation, drinking contaminated water as well as ingestion of contaminated food items. The persistent sulfone and sulfoxide degradates are also toxic to mammals, thereby increasing the potential risk from the application of disulfoton. The registrant has suggested that mammals as well as birds can consume an equivalent of 2 to 3 LD50's as part of their diet and not be adversely effected. Although this may be true for a population of laboratory test animals, individuals will vary in their sensitivity and can die as a result of inability to avoid predation, secure prey or thermoregulate. Numerous pen studies were conducted with cottontail and jack rabbits exposed to single applications ranging from 1 to 25 lbs ai/A. While no mortality occurred to cottontails, at the 2 lb ai/A rate and above jackrabbits suffered 100% mortality. Secondary poisoning did not occur when the jackrabbit carcasses were fed to a number of avian and mammalian carnivores. The apparent difference between the pen study results and the acute mortality predicted in the risk assessment screen is largely due to the possibility that the calculated 1 day LC50s (ranging from 2 to 12.7 ppm) discounts the rapid metabolism of disulfoton. However, using the demeton LC50 of 320 ppm with its wide ranging confidence interval (0 to infinity) also adds uncertainty to the question of disulfoton's acute risk to mammals.

Chronic risk to mammals is predicted. As was previously discussed in the above acute and chronic sections for birds, there are several reasons why small mammals are likely to be at even greater risk, not the least of which is the extremely low NOAEC of 0.8 ppm. All modeled and empirically derived residues for all sites exceed the chronic risk level of concern for mammals. Finally, the persistence of the sulfone and sulfoxide degradates, which are also toxic to mammals, increases the likelihood of chronic risk to mammals.

Non-target Insects: Disulfoton and its sulfoxide and sulfone degradates are moderately to highly toxic to bees, however a residual study with honey bees indicated no toxicity for applications up to 1 lb ai/A.

Freshwater Fish: Most of the modeled use patterns did not exceed the acute risk levels of concern for freshwater fish. Only the two soil applications at 4.0 lb ai/A of the liquid formulation exceeded acute risk. All other scenarios exceeded the restricted use and endangered species levels of concern. There is, however, a large amount of variation in freshwater fish species' sensitivity to disulfoton, as evidenced in the toxicity data table. The microcosm study included bluegill sunfish. Following the last application of 30 ppb, 10% of the fish died. Several kills of freshwater fish have occurred from applications of disulfoton to different crops-- both as registered uses as well as from misuse.

Chronic risk to freshwater fish may occur from uses where single application rates are equal to 4 lb ai/a and from 3 applications of 1 lb ai/A.. The single freshwater fish species (rainbow trout), for which chronic toxicity data was available, demonstrates significantly less sensitivity to disulfoton than several other species (bluegill sunfish, bass, guppy). Therefore, an estimated chronic NOEC value was calculated using the chronic to acute ratio for the rainbow trout, as described earlier. Based on the estimated chronic NOAEC for bluegill, chronic effects would

occur from the present uses on tobacco, foliar treatments of potatoes and repeated soil treatments of cotton. Christmas tree plantations were not modeled, however the high application rate (possibly 47 lbs ai/A) and sloped land may be a potentially risky site.

Freshwater Invertebrates: All modeled crop scenarios exceeded the acute risk level of concern, but the highest risk quotients were less than 10. Again, the risk is further increased due to the toxicity and persistence of the degradates of disulfoton. Microcosm study results indicated that there was recovery of most phyla examined at 3 ppb and long term impacts for most phyla at 30 ppb. Therefore 10 ppb is probably a concentration where short term effects will occur, but recovery can be anticipated.

Chronic risk to freshwater invertebrates is predicted to from the use of disulfoton. All of the modeled crop scenarios greatly exceeded the level of concern, sometimes by a factor of several hundred. Invertebrate life-cycle testing with disulfoton shows that it impacts reproductive parameters (number of young produced by adults) in addition to survival and growth. The 21 day average EECs for the modeled sites ranged from 4.3 to 17.9 ppb. For the most part these EECs are within the range where recovery was occurring in the microcosm. However there is uncertainty as to how much more reliable the microcosm may be as a predictor of safety.

Estuarine and Marine Fish: Although acute and restricted risk levels of concern were not exceeded for estuarine and marine fish, the endangered species level of concern was exceeded for several of the modeled crop scenarios (cotton, potatoes and wheat). As was note among the freshwater fish, there can be substantial species differences in sensitivity to disulfoton. Therefore, it is possible that the single marine/estuarine fish species tested (Sheepshead minnow) does not fully represent the true range of sensitivity found in a marine or estuarine ecosystem, and this assessment may therefore underestimate the true risk to marine/estuarine fish. There is also some uncertainty in using the PRZM/EXAMS EECs derived for ponds to predict exposure to marine/estuarine organisms. The scenarios modeled are based on hydrologic data for freshwater habitats. The exposure in a marine or estuarine habitat may be higher or lower than that predicted for a freshwater habitat, resulting in higher or lower risk to marine/estuarine organisms.

Chronic risk to estuarine and marine fish is predicted from the use of disulfoton. Both early life-stage and full life-cycle testing demonstrated a variety of effects at low levels of disulfoton. Risk quotients based on the early life-stage toxicity endpoint exceeded the level of concern for cotton, potatoes and tobacco. The highest risk quotients were based on numerous life-cycle toxicity endpoints --fecundity, hatching success and growth; consequently the chronic level of concern was exceeded for all modeled scenarios. Estuarine fish spawning in the upper reaches of tributaries of bays would be a greatest risk. However the likelihood of this risk is uncertain for several reasons: 1) the required time the adults must be exposed to disulfoton in order for their reproductive systems to be effected and 2) the residency time of disulfoton residues in tidal or flowing water. Even if adults are effected after an exposure of only a week, disulfoton may be moved out of an area within several days.

Estuarine and Marine Invertebrates: Three of the five modeled scenarios (cotton, potatoes, and tobacco) resulted in exceedences of the estuarine/marine invertebrate acute risk level of concern. All the remaining uses exceeded the restricted use level of concern. Similar uncertainty

exists as to the validity of the exposure scenario for invertebrates as was just described for estuarine fish.

Chronic risk to marine/estuarine invertebrates is predicted. All of the modeled crop scenarios exceeded the chronic level of concern. The much shorter life cycle of invertebrates as compared to fish, increases the likelihood that only a brief exposure (a few day or even hours) of adults to disulfoton concentrations around the NOAEC is sufficient to negatively impact reproduction. The degree to which the freshwater microcosm is a predictor of safety for the estuarine invertebrates is highly uncertain. Only the mysid shrimp has been tested and it was acutely and chronically less sensitive than freshwater *Daphnia*. Therefore, on the basis of this limited data, the chronic impact to estuarine invertebrates not only appears to be lower than for freshwater invertebrates, but is likely to be low.

Nontarget Plants: Currently, terrestrial and aquatic plant testing is not required for pesticides other than herbicides except on a case-by-case basis. Nontarget plant testing was not required for disulfoton, so the risk to plants could not be assessed at this time. There are phytotoxicity statements on the label, however, as well as some incident reports of possible plant damage from the use of disulfoton, so there is the potential for risk to nontarget plants.

Summary of Risk Assessment of North Carolina 24c for use in Christmas Tree Farms

Christmas tree farms and the adjacent areas -- forests and/or pasture -- provide excellent habitat for a great variety of wild life. The use of granular disulfoton suggests that there is acute risk to small birds and mammals. The North Carolina Christmas Tree community has submitted numerous testimonials emphasizing the ever increasing numbers and diversity of wild life. This includes game animals such as turkey rearing young amidst the Christmas trees, song birds, rodents and foxes. Although this information is intended to suggest there is little or no negative impact from not only disulfoton, but other pesticides or cultural practices as well, the Agency would prefer to receive documented surveys or research before making a final determination.

There were no detections of disulfoton or its metabolites in the ground-water monitoring study conducted in North Carolina by the North Carolina Departments of Agriculture and Environment, Health, and Natural Resources. Seven Christmas tree, one wheat, and two tobacco growing areas were sampled for disulfoton residues. Limitations of the study include that sites were sampled only twice and the limits of detections were high (e.g., > 1.0 µg/L) for some of disulfoton analytes. Uncertainties associated with the study include whether two samples from eight wells are adequate to represent the ground-water concentrations of disulfoton residues, did DRASTIC correctly identify a site's vulnerability, and were the wells placed down-gradient of the use areas.

The use of Disulfoton 15 G in Christmas tree farms at this time cannot be modeled for potential surface water contamination. EFED assumes the estimated concentration for the North Carolina 24 (c) use pattern -- 2.75 lbs ai/ A unincorporated -- may be similar to the values for the single 4.0 lb ai/A incorporated application of granular disulfoton to tobacco. Based on this assumption there is acute risk to aquatic invertebrates and chronic risk to freshwater fish and aquatic invertebrates.

The North Carolina Christmas tree industry submitted two surveys of streams in the Westerns region. The surveys followed a protocol for looking at macro invertebrates to assess the impact of agricultural practices associated with Christmas tree farming. In summary, the two surveys suggests that when conservation measures associated with Christmas tree farming in the Western counties of North Carolina are implemented, there may be only slight, short term impact to aquatic macro invertebrates from disulfoton use. Aquatic macro invertebrates appear to have the capacity to recover from any impact that could be caused by disulfoton use on Christmas trees in Western North Carolina.

C. Mitigation

The use of disulfoton at single application rates of 1.0 lb ai/A and greater, and multiple application rates of 0.5 lb ai/A and greater, poses an acute risk to birds, mammals, fish, and aquatic invertebrates, as well as to nontarget insects. EFED believes that amending label rates to the lowest efficacious rate as a maximum, as well as restricting the number of applications per year and lengthening the application interval, would reduce acute risk to terrestrial and aquatic organisms. Requiring in-furrow applications wherever feasible, and eliminating banded applications of granular disulfoton with narrow row spacing, would also reduce the risk to nontarget organisms, especially birds and mammals. Eliminating aerial applications of disulfoton and imposing buffer strips around aquatic habitats would reduce the risk to aquatic organisms. Risk to bees and other nontarget insects could be lowered by not applying disulfoton when the insects are likely to be visiting the area.

Qualitative comparative ecological risk assessment between present and proposed disulfoton uses.

Bayer has proposed the following changes to some use patterns assessed by the Agency that would reduce the ecological risk from Di-syston 8E:

- *cancel aerial applications to cotton and wheat.
- *cancel foliar applications to cotton.

The table reflects additional changes proposed by Bayer.

Table 1 Comparison of present and proposed changes in 4 use patterns of Di-syston 8E	
Present Use	Proposed Use
Rate/Number of Applications/Interval/Incorp. Depth/method ¹	Rate/Number of Applications /Interval/Incorp. Depth/method ¹
lb.ai/A/ #app./ days/ inches	lb.ai/A/ #app./ days/ inches
cotton 1.0/3/21/0/gs	cotton 1.0/1/-/0/gs
potatoes 4.0/2/14/2.5/gs	potatoes 3.0/1/-/2.5/gs
potatoes 1.0/3/14/0/af	potatoes 0.5/3/14-/0/af
wheat 0.75/2/30/0/gs	wheat 0.75/1/-/0/gs
¹ Method of application: f = foliar and s = soil; gs = ground spray, af = aerial spray-foliar	

Risk to Birds and Mammals

Canceling aerial application to wheat and cotton reduces significantly the potential for exposing edge of field food items and vegetation. Canceling foliar applications to cotton reduces the opportunity for exposure, by reducing the food items that are directly sprayed. As the discussion below explains, field monitoring indicates that ground spray to soil reduces substantially the residues on food items from those residues predicted from the nomograph.

Potato aerial foliar at 0.5 lb ai/acre

Biological field testing (MRID 41359101) suggests that significant acute risk to mammals from foliar sprays is unlikely at a single application of 1 lb ai/acre or lower. Reducing the potato rate from 1 lb ai/acre 3 times, to 0.5 lb ai/acre 3 times, substantially lowers the acute risk to mammals.

Wheat, potato and cotton ground spray to soil

Field residue monitoring (MRID 41118901) indicates that residues on food items following ground applications to soil are significantly lower than would be expected from direct application to vegetation. Peak residues following the first of two treatments at 3 lb ai/acre (in furrow) ranged from 0.9 ppm (invertebrates and edge of field vegetation), to 26 ppm (potato foliage). The second treatment at 3 lb ai/acre side dressing (6-7 weeks later) resulted in peak residues of 1.8 (invertebrates), 44 ppm potato foliage, and 54 ppm (edge of field vegetation). The residues from these applications are not only lower than those estimated using the nomograph, but also lower than the field residues resulting from foliar applications. In the foliar residue monitoring study (3 aerial applications at 1.0 lb ai/acre) the peaks were: invertebrates (16 ppm) and vegetation (154 ppm). The proposed changes would greatly reduce exposure terrestrial species.

Table 2 Comparison of **potential** acute and chronic risk resulting from proposed changes in 4 use patterns of Disyston 8E for birds and mammals

Present Use	Birds		Mammals		Proposed Use	Birds		Mammals	
Rate/Number of Apps/Interval/Incorp. Depth/method ¹	ac	ch	ac	ch	Rate/Number of Apps/Interval/Incorp. Depth/method ¹	ac	ch	ac	ch
lb.ai/A/ #app./ days/ inches					lb.ai/A/ #app./ days/ inches				
cotton 1.0/3/14/0/gs	E	Y	R	Y	cotton 1.0/1/-/0/gs	no	Y	E	Y
potatoes 4.0 /2/14/2.5/gs	R	Y	A	Y	potatoes 3.0/1/-/2.5/gs	E	Y	R	Y
potatoes 1.0/3/14/0/af	R	Y	A	Y	potatoes 0.5/3/14-/0/af	R	Y	R	Y
wheat 0.75/2/30/0/gs	E	Y	R	Y	wheat 0.75/1/-/0/gs	no	Y	E	Y

¹ Method of application: f = foliar and s = soil; g = ground and a = aerial

Acute = ac; Chronic = ch

Acute risk LOC is exceeded=A; Restricted use LOC is exceeded=R; Endangered Species LOC is exceeded=E; No acute LOC is exceeded= no; LOC for chronic risk is exceeded=Y; LOC for chronic risk is not exceeded=N.

Risk to fish and aquatic invertebrates

The following table summarizes the results of modeling the proposed new uses. The EECs were reduced from the present registered use patterns:

Table 3 Tier II Upper Tenth Percentile EECs for Disulfoton Parent based on proposed new maximum label rates and management scenarios for cotton, potatoes, and spring wheat in farm pond. Estimated using PRZM3/EXAMS.								
Crop	Disulfoton Application	Concentration (µg/L) (1-in-10 annual yearly maximum value)						Mean of Annual Means (µg/L)
	Rate/Number of Apps/Interval/Incorp. Depth/method ¹							
	lb.ai/A/ #/ days/ inches	Peak	96-Hour Avg.	21-Day Avg.	60-Day Avg.	90-Day Avg.	Annual Avg.	
Cotton	1.00/1/-/0/gs	10.31	9.38	6.83	3.54	2.42	0.62	0.23
Potatoes	3.00/1/-/2.5/gs	2.42	2.18	1.67	0.84	0.57	0.15	0.12
Potatoes	0.5/1/-/0/af	7.51	6.62	5.20	3.45	2.42	0.62	0.57
Spr.Wheat	0.75/1/-/0/gs	1.02	0.91	0.67	0.41	0.28	0.08	0.05

¹ Method of application: f = foliar and s = soil; g = ground and a = aerial

The following tables reflect a qualitative comparative risk assessment for aquatic and estuarine organisms.

Table 4 Comparison of potential acute and chronic risk resulting from proposed changes in 4 use patterns of Di-syston 8E for freshwater fish and invertebrates									
Present Use	Fish		Invertebrates		Proposed Use	Fish		Invertebrates	
Rate/Number of Apps/Interval/Incorp. Depth/method ¹	ac	ch	ac	ch	Rate/Number of Apps/Interval/Incorp. Depth/method ¹	ac	ch	ac	ch
lb.ai/A/ #/ days/ inches					lb.ai/A/ #/ days/ inches				
cotton 1.0/3/14/0/gs	R	Y	A	Y	cotton 1.0/1/-/0/gs	R	N	A	Y
potatoes 4.0/2/14/2.5/gs	R	Y	A	Y	potatoes 3.0/1/-/2.5/gs	E	N	A	Y
potatoes 1.0/3/14/0/af	R	Y	A	Y	potatoes 0.5/3/14-/0/af	R	N	A	Y
wheat 0.75/2/30/0/gs	R	N	A	Y	wheat 0.75/1/-/0/gs	no	N	R	Y
¹ Method of application: f = foliar and s = soil; g = ground and a = aerial Acute = ac; Chronic = ch Acute risk LOC is exceeded=A; Restricted use LOC is exceeded=R; Endangered Species LOC is exceeded=E; No acute LOC is exceeded= no; LOC for chronic risk is exceeded=Y; LOC for chronic risk is not exceeded=N.									

Table 5 Comparison of potential acute and chronic risk resulting from proposed changes in 4 use patterns of Di-syston 8E for estuarine fish and invertebrates									
Present Use	Fish		Invertebrates		Proposed Use	Fish		Invertebrates	
Rate/Number of Apps/Interval/Incorp. Depth/method ¹	ac	ch	ac	ch	Rate/Number of Apps/Interval/Incorp. Depth/method ¹	ac	ch	ac	ch
lb.ai/A/ #/ days/ inches					lb.ai/A/ #/ days/ inches				
cotton 1.0/3/14/0/gs	no	Y	A	Y	cotton 1.0/1/-/0/gs	no	Y	A	Y
potatoes 4.0/2/14/2.5/gs	no	Y	R	Y	potatoes 3.0/1/-/2.5/gs	no	N	R	N
potatoes 1.0/3/14/0/af	no	Y	A	Y	potatoes 0.5/3/14-/0/af	no	Y	A	Y
wheat 0.75/2/30/0/gs	no	Y	A	Y	wheat 0.75/1/-/0/gs	no	N	E	N
¹ Method of application: f = foliar and s = soil; g = ground and a = aerial Acute = ac; Chronic = ch Acute risk LOC is exceeded=A; Restricted use LOC is exceeded=R; Endangered Species LOC is exceeded=E; No acute LOC is exceeded= no; LOC for chronic risk is exceeded=Y; LOC for chronic risk is not exceeded=N.									

Summary

EFED supports the proposed use modifications, and concurs that generally they reduce risk to nontarget organisms to varying degrees. Although there remains the concern for hypersensitive birds and mammals, the acute risk to most birds and mammals is reduced substantially. The greatest risk reduction to fish and aquatic invertebrate are soil applications to potatoes and wheat. There appears to be little changes in acute risk to aquatic organisms from the proposed modifications to cotton and potatoes (aerial application). Chronic risk to terrestrial and aquatic organisms are likely to be reduced; but with less certainty, because the duration of exposure required to produce adverse chronic effects in the field are not available.

Data Gaps:

The following environmental fate requirements are not satisfied for disulfoton, D. sulfoxide, and D. sulfone:

162-3: Anaerobic Aquatic Metabolism

162-4: Aerobic Aquatic Metabolism

163-1: Mobility - Leaching and adsorption/desorption for D. sulfone and D. sulfoxide.

Additionally, there is limited environmental fate data available for the sulfone and sulfoxide degradates. Data on the fate of these degradates in soil and water would allow additional characterization of the risks they present to nontarget organisms.

The following ecological effects data requirements are not satisfied for disulfoton:

122-1: Tier I Terrestrial Plant Testing

122-2: Tier I Aquatic Plant Testing

(123-1 and 123-2, Tier II testing, are reserved pending the results of Tier I testing).

71-3 Wild mammal testing subacute dietary (LC50).

The value added for the wild mammal test is high. This study could resolve the issue between the calculated 1 day LC50 (ranging from 2- 12 ppm) derived from the acute rat acute oral of 1.9 mg/kg and the demeton LC50 study (320 ppm) with 95% C.I. (0 to infinity). The risk assessment for mammals would be refined with greater certainty.

Manufacturing-Use Products

“This pesticide is extremely toxic to birds, mammals, fish and aquatic invertebrates. Do not discharge effluent containing this product into lakes, streams, ponds, estuaries, oceans, or public waters unless this product is specifically identified and addressed in an NPDES permit. do not discharge effluent containing this product to sewer systems without previously notifying the sewage treatment plant authority. For guidance, contact your State Water Board or Regional Office of the EPA.”

End-use Products

Non granular products: “This pesticide is extremely toxic to birds, mammals, fish and aquatic invertebrates. Do not apply directly to water, or to areas where surface water is present or to intertidal areas below the mean high-water mark. Drift and runoff may be hazardous to aquatic organisms in neighboring areas. Do not contaminate water when disposing of equipment washwater or rinsate.”

Granular products: This pesticide is extremely toxic to birds, mammals, fish and aquatic invertebrates. Collect granules spilled during loading or application.. Do not apply directly to water, or to areas where surface water is present or to intertidal areas below the mean high-water mark. Runoff may be hazardous to aquatic organisms in neighboring areas. Do not contaminate water when disposing of equipment washwater or rinsate.”

Disulfoton Bee Mitigation - Suggested Precautionary Label Language for non granular products:
“This pesticide is toxic to bees. Application should be timed to coincide with periods of minimum bee activity, usually between late evening and early morning. ”

Surface Water Advisory

“This product may contaminate water through drift of spray in wind. This product has a high potential for runoff for several months. Poorly draining soils and soils with shallow watertables are more prone to produce runoff that contains this product.”

Labels for farmers should add the following to the previous statement:

“A level, well maintained vegetative buffer strip between areas to which this product is applied and surface water features such as ponds, streams, and springs will reduce the potential for contamination of water from rainfall-runoff. Runoff of this product will be reduced by avoiding applications when rainfall is forecasted to occur within 48 hours.”

Labels for home owners should add the following to the previous statement:

“Avoid applying this product to ditches, swales, and drainage ways. Runoff of this product will be reduced by avoiding applications when rainfall is forecasted to occur within 48 hours.

Ground Water Advisory

Note to CRM: Disulfoton residue detections in ground water range from 0.04 to 100 ppb; detections are up to 300 times the Health Advisory (0.3 ppb). There is a high potential for degradates to contaminate ground water. Because disulfoton degradates are persistent, apparently mobile, and parent disulfoton has been found in ground water, a ground water label advisory is required. The following label language is appropriate:

"Disulfoton is known to leach through soil into ground water under certain conditions as a result of label use. Use of this chemical in areas where soils are permeable, particularly where the water table is shallow, may result in ground-water contamination."

Spray Drift

Since disulfoton can be applied aerially, current cautionary labeling for the spray drift of aerially applied pesticides must be used.

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1. Use Characterization for Disulfoton

Disulfoton is a systemic organophosphate insecticide, acaricide (miticide) registered for use to control aphids, thrips, mealybugs, other sucking insects, and spider mites on a variety of terrestrial food crops (coffee, peppers, broccoli, brussels sprouts, cabbage, cauliflower, lettuce, spinach, asparagus, pecan, radish, and raspberries), terrestrial food and feed crops (tomato, barley, corn, oats, triticale, wheat, cotton, peanut, peas, sorghum, soybeans, potatoes, beans, and lentils), terrestrial feed crops (bermudagrass, and alfalfa), and terrestrial nonfood crops (Christmas tree plantations, ornamentals, and non-bearing fruit). The total use of disulfoton for 1997 was approximately 1.7 million lbs ai. Cotton has the greatest use of disulfoton (420,000-840,000 lb ai/yr), accounting for 61% of the disulfoton market. Wheat has the next largest percentage of the market, at 16% (180,000-354,000 lb ai/yr). The largest use state is California (16% of the market, 272,000 lb ai/yr), followed by Louisiana (11% of the market, 187,000 lb ai/yr). Rankings of disulfoton usage by crop and by state are provided in Appendix I.

Disulfoton is formulated as 15% granules, 8% emulsifiable systemic, 95% cotton seed treatment, systemic granules (1, 2, 5, 10%), and 68% concentrate for formulating garden products. Applications are generally soil applied: in-furrow, broadcast, or row treatment followed by 2-3 inch soil incorporation. It can also be applied as a foliar treatment and in irrigation water. Cotton seeds can also be directly treated and planted. Disulfoton can be applied in multiple applications (up to three) at intervals from 7 to 21 days depending upon the crop. Application rates typically range from about 0.5 to 4.00 lb ai/A. A Section 24(c) Registration for North Carolina Christmas trees allows up to 4.5 lb ai/A and for the same use, the Federal Section 3 Registration allows for greater than 57 lb ai/A.

2. Exposure Characterization

A. Chemical Profile

1. Common name: disulfoton
2. Chemical name: O,O'-diethyl-S-[2-ethylthio)ethyl]phosphorothioate
3. Trade Names: Di-Syston
4. Physical/Chemical properties:
 - Molecular formula: $C_8H_{18}O_2PS_3$
 - Molecular weight: 274.39
 - Physical state: colorless liquid
 - Specific gravity: 1.144 at 20° C.
 - Henry's Law Constant: 2.60E-6 Atm. M³/Mol (measured)
 - Boiling point: 62° C at 0.01 mmHg
 - Vapor pressure: (20° C) = 1.8×10^{-4} mmHg
 - Solubility: in water at 20° C = 25 ppm; miscible in n-hexane, dichloromethane, 2-propanol, toluene

B. Environmental Fate Assessment

I. Environmental Fate and Chemistry Data

The environmental fate and chemistry data base for disulfoton is incomplete for the parent compound. Less fate data are available for the degradation products. The major routes of dissipation are chemical reaction and microbial degradation in aerobic soil and aqueous photolysis and soil photolysis. Volatilization from soil and water is not expected to be significant. Data are unavailable for aerobic and anaerobic aquatic environments. The anaerobic soil metabolism studies have been submitted to the Agency, and will be reviewed by EFED. Disulfoton is essentially stable to hydrolysis at 20°C at the three pH values tested but is influenced by temperature as hydrolysis is fairly rapid at 40°C. The overall results of these mechanisms of dissipation appear to indicate that disulfoton has low persistence. Limited data suggests that the degradates are much more persistent. Disulfoton also appears to be more persistent under anaerobic soil conditions than aerobic soil conditions. The adsorption/desorption studies indicate that disulfoton is slightly to somewhat mobile depending upon the soil. Aged leaching studies suggested that D. sulfoxide and D. sulfone degradates did not leach which is inconsistent with the field data, terrestrial field dissipation studies showed that both degradates leached. Sulfoxide and sulfone degradates of other organophosphate pesticides tend to be more mobile than the parent compound. The individual studies are summarized below.

Hydrolysis (161-1)

The primary hydrolysis products were the disulfoton oxygen analog (POS) at pH 4, a mixture of des-ethyl disulfoton metabolites of which the major one is des-ethyl POSO₂ at pH 7 and a product obtained at pH 9 which converted to 2-2- (ethylsulfonyl) ethane sulfonic acid upon treatment with potassium permanganate. The reported hydrolysis half-lives are 1174 days, 323 days, and 231 days in sterile aqueous buffered solutions at pH's 4, 7, and 9, respectively, for a 30 day study. Consequently, disulfoton is essentially stable to abiotic degradation at 20°C. At 40°C, the half-lives were 30, 23.2, and 22.7 days at pH 4, 7, and 9, respectively. The hydrolysis guideline requirement (161-1) is fulfilled (MRID 00143405).

Photodegradation in water (161-2)

Disulfoton had a $T_{1/2}$ of 93 hours. The half-life for aqueous photolysis (corrected for the dark control) is 93 hours in a pH 5 buffered solution exposed to natural sunlight (Latitude 38.05 N; Longitude 84.30 W.; October 5-15, 1987; average temperature $19.4 \pm 2.08^\circ\text{C}$). For the purpose of modeling (in the water body), the rate of disulfoton photolysis in water was considered. Disulfoton sulfoxide was the major degradation product. Control (dark) samples degraded with a half-life of > 300 hours. Both reactions followed zero-order kinetics (independent of concentration). The guideline requirement for photo-degradation in water (161-2) is fulfilled (MRID 40471102).

Photodegradation on soil (161-3)

The half-life of disulfoton was 2.4 days on sandy loam soil plates exposed to natural sunlight. The primary photoproduct was disulfoton sulfoxide in irradiated and dark samples. Less than 10% disulfoton oxygen analog sulfoxide and disulfoton sulfone were detected in the light exposed samples after two days of irradiation. MRID 40789701 was rejected on 8/23/89 since the proportion of metabolites formed was not presented in the study report. The registrant provided this information in a letter dated 2/11/92. The photo-degradation on soil data requirement (161-3) is fulfilled (MRID 40471103).

Aerobic soil metabolism (162-1)

Literature suggests that disulfoton is transformed in soil via microbial metabolism and chemical oxidation (Howard et al., 1991). Primary transformation products are D. sulfoxide and D. sulfone. Five oxidative metabolites, that persisted for more than 12 weeks (84 days), have been identified in a paddy soil (Howard et al., 1991). Data generally suggests that in soil disulfoton will initially decline rapidly in soil, but this decline slows with time. Reported "half-lives" of disulfoton tend to be generally less than 5 days. In soil, the metabolites, D. sulfoxide and D. sulfone, appear to be more persistent >17 days and >150 days, respectively (MRID# 4437391).

The registrant has submitted a several studies to assess the aerobic metabolism rate in soil (MRID #s 43800100, 40042201; 41585101). The aerobic soil half-life was calculated by the registrant to be 15.6 days, however, the reaction did not follow first-order kinetics (MRID 43800101). It was recalculated (see next paragraph). Less than 20% of the amount applied remained 7 days after treatment; <3% remained 60 days after treatment. The major degradates are the sulfoxide (58.7%) at 7 days, and sulfone (72%) at 90 days. At the end of the study (367 days), the sulfone was present at 35% of the applied amount, and the sulfoxide at 2% of the applied amount. Except for the sulfone and sulfoxide degradates, residues were not detectable at 367 days. The aerobic soil metabolism guideline requirement (162-1) is fulfilled (MRID 43800101).

As noted above there is an issue as to whether the decline of disulfoton in soil follows first-order kinetics in this study (MRID 43800101). The information reported in MRID 43800101 suggests non-first order kinetics and a half-life less than the "calculated" 15.6 days as indicated. The 15.6 day half-life was calculated by the registrant and only represents a portion of the data (days 0 through 90, days 122, 241, and 367 were not included). The slope (decay rate constant, k) of the transformed (natural log or \ln) ($\ln C(t) = \ln C_0 - kt$, where C_0 is the initial concentration, C is concentration, and t is time) was significant with $p=0.0001$ and a r^2 of 0.888. From a statistical standpoint, a first-order model using transformed data provides a reasonable estimate of the decline rate. However, the time that the initial pesticide concentration reaches half the initial concentration (e.g., half-life) is less than the 15.6 days suggested by the analysis of the transformed data. The decay rate of disulfoton appears to follow the pseudo first-order type kinetics over the entire study duration better than when nonlinear regression is applied to untransformed data ($C=C_0e^{-kt}$) where C_0 is the initial concentration, C is concentration, t is time, and k is the decay rate constant. The parameter k was estimated by non-linear regression of C versus time. The half-life (when $C/C_0 = 0.5$) was estimated to be 2.57 days ($r^2 = 0.93$). The linear regression of the \ln -transformed data tended to over estimate disulfoton residues with time whereas the non-linear regression of the non-transformed data under estimated the disulfoton residues with time. Approximately, 10 percent of applied radio-labeled disulfoton (Di-

Syston) was reported to be in the sulfoxide state at time zero (day 0 < then 6 hours) which suggests rapid oxidation to the corresponding sulfoxide metabolite.

Two additional aerobic soil metabolism studies (MRID#s 40042201; 41585101) submitted by the registrant, determined to be supplemental studies by EFED, also provided additional information which was considered. These studies had estimated aerobic half-lives of 2.4 and 1.9 days, respectively. A half-life of 1.9 days (MRID 41585101) was estimated using the ln-transformed disulfoton percentages from only the first three days (0, 0.25, 1, and 3 days) of the experiment, the remaining days 7, 14, 30, 90, 189, 270 are not considered. The decline of parent disulfoton in these studies also appeared not to follow first-order kinetics, but pseudo first-order kinetics.

The registrant indicated in a response (3/8/99 To: P. Poli, From: J.S. Thornton) that the half-lives for the studies submitted as MRID #43800101 and 41585101 were 5.5 and 4.1 days, respectively. Because these half-lives are longer (more conservative) than those estimated by EFED (see above), these values were used in the modeling for the water assessment.

The metabolites (D. sulfoxide and D. sulfone) tended to be more persistent with $T_{1/2}$ of ~17 days and ~150 days, respectively (MRID# 4437391). The registrant indicates, non-guideline study (modeling exercise) that the DT50 for disulfoton, sulfoxide, and sulfone is 5.5, 17, and 150 days, respectively (MRID 4437391). The equations used to estimate these values were not specified, thus, the DT50s (rate constants) could not be confirmed.

Anaerobic soil metabolism (162-2)

Several anaerobic soil metabolism studies have been submitted to the EPA (MRID#s 43512201, 43042503). The studies indicate that disulfoton is more persistent under anaerobic soil conditions compared to aerobic soil conditions. EFED will conduct a detailed review of these studies.

Anaerobic aquatic metabolism (162-3)

This study (MRID 43042503) cannot be used to fulfill data requirement 162-3. Material balances were too low, declining from 106% immediately post-treatment to 78.7% at 202 days. Only 65% of the intended application was available at the start of the study. The study cannot be upgraded; a new anaerobic aquatic study or an anaerobic soil metabolism study must be submitted for disulfoton.

Aerobic aquatic metabolism (162-4)

No data on aerobic aquatic metabolism of disulfoton or its metabolites have been submitted. This information must be submitted by the registrant.

Mobility - Leaching and Adsorption/Desorption. (163-1)

Adsorption/desorption studies of disulfoton indicated that it is slightly mobile to somewhat mobile depending on the soil. Adsorption/desorption coefficients of various soil types are

tabulated below.

Table 1. Kd and Koc Adsorption/Desorption Values for Disulfoton for four soils				
Soil Texture	Silt Loam	Sand	Clay Loam	Sandy Loam
Kd	6.85	4.67	4.47	9.66
Koc (ads.)	449	888	386	483
Koc (des.)	629	1340	547	791

The average organic carbon normalized Freundlich Kads was estimated to be 551.5 mL/g soil carbon from the data summarized in the above Table 1. The Koc (ads.) model generally appears to be appropriate as Kads increase with organic carbon content and the 1/n term in the Freundlich equation were close to 1 (so Kads ~ K_d).

In a second report, # 66792, parent Freundlich K values (7.06 to 14.29) indicate that disulfoton is adsorbed to a moderate degree which also reflects low mobility in soils. The average Di-Syston R_f value was 0.22 on six soils which also indicates low mobility of the parent disulfoton. The correlation coefficients describing the degree of data conformity to the Freundlich equation ranged from 90.3 to 99.9%. The 1/n values for the three soils were 1.002, 0.980, and 0.975. Calculated Kocs were 641, 752, and 839. The mobility-leaching and adsorption/desorption guideline requirement (163-1) is fulfilled (MRID #443731-03 and 00145469). These data were also recorded in Bayer's 11/30/93 letter to SRRD, MRID - 430425-00 pages 3 and 4.)

Adsorption/desorption data are needed for D. sulfoxide and D. sulfone.

Mobility - Leaching of Aged Di-Syston (163-1)

This 1986 study (Acc. # 00145470) was not conducted in accordance with acceptable guidelines, and the 1986 results were not consistent with current data using guideline studies. Recent data indicate that the degradates will leach to lower depth, but the 1986 study indicated no leaching of sulfoxide and sulfone degradates. A new column leaching study is not required, because other existing data fulfill the requirement.

Laboratory Volatility (163-2)

Disulfoton volatilized at maximum of 0.026 and 0.096 $\mu\text{g}/\text{Cm}^2/\text{hr}$ from sand soil adjusted to 25% and 75% of field capacity at 0.33 bar respectively, incubated in dark for 21 days at 25 °C with an air flow of approximately 300 mL/minute. Maximum volatilization occurred within 24 hours following treatment. The vapor pressure of disulfoton was reported to be 7.2×10^{-5} mBar at 20 °C and 1.3×10^{-5} mBar at 25 °C. Freundlich Kads for the sand soil was determined to be 0.172. The guideline requirement for laboratory volatility (163-2) has been fulfilled (MRID 42585802)

Field Volatility (163-2)

Maximum concentration observed in air at 1 foot above ground was 22.2 ng/L. Disulfoton concentrations, after 6 hours, at the 5 foot level were not detectable. Bayer, Inc. submitted additional data, e.g., ads./des. Kds, and cloud covering on the days of the experiment. The guideline requirement for field volatility (163-2) has been fulfilled (MRID 40471105).

Terrestrial Field Dissipation (164-1)

Disulfoton applied at 8 lbs./ac dissipated with a $T_{1/2}$ of 2 to 4 days from the upper 6 inches of sand/sandy loam and loamy sand/sandy loam plots in California. Parent disulfoton was detected only in the upper 6 inches of soil, the sulfoxide and sulfone degradates were detected to a depth of 18 inches. The guideline requirement for terrestrial field dissipation (164-1) has been fulfilled (MRID 43042502).

Fish Bioaccumulation (165-4)

From 60.8 to 85.9 ppb ^{14}C residues in edible fish and 38.1 to 39.9 ppb in the inedible fish tissues were not characterized. After 14 days depuration, fillet contained 21% of the applied residues, viscera 18.1%, and whole fish 22%. Bioconcentration factors were 460X for whole fish, 700X for viscera, and 460X for fillet. Bayer submitted data, at the Agency's request, which indicated that there was no mortality and no growth during the study. The bioaccumulation guideline (165-4) has been partially fulfilled (MRID 43042501, 43060101, 40471106, and 40471107). No further bioaccumulation testing is required for parent disulfoton, however, bioaccumulation information, or at least K_{ow} determination, for the sulfone and sulfoxide degradates would be helpful for risk assessment purposes.

Foliar Dissipation (Non-Guideline Study - Supporting Information)

The foliar dissipation rate of 3.3 days is based on field monitoring data (MRID #41201801). Disulfoton was aerially applied to potatoes 3 times at 1 lb ai/acre in Michigan. Potato foliage was collected from five different treated fields with six sampling stations in each field. Samples were collected the day before and the day after each of the three treatments, and then on day 7 and 14 after the third (final) treatment. The foliar dissipation rate estimates are based on the samples collected after the third treatment. The following table shows the average residue levels on potato foliage on days 1, 7 and 14 from the five fields, across all 6 sample stations and the average for all fields.

EFED determined that the 90th percentile upper bound foliar dissipation half-life for disulfoton of 3.3 days is used for both terrestrial exposure assessment, and in PRZM-EXAMS when foliar dissipation is applicable

Table 2. Residue data and the calculated foliar dissipation half-life based on measured residues of disulfoton on potato foliage after the third application. Residues in µg/g (ppm).

Time	field 1*	field 2*	field 3*	field 4*	field 5*	average of all fields
day 1	51	36	34	40	40	40
day 7	4.8	4.7	8.5	5.3	5.9	5.8
day 14	1	0.9	1.9	1.6	4.2	1.9
half-life (days)	2.3	2.4	3.1	2.8	4	2.98 upper 90% CL 3.3

* average across all stations

C. Terrestrial Exposure Assessment

For pesticides applied as a nongranular product (e.g., liquid, dust), the estimated environmental concentrations (EECs) on food items following product application are compared to LC50 values to assess risk. The predicted 0-day maximum and mean residues of a pesticide that may be expected to occur on selected avian or mammalian food items immediately following a direct single application at 1 lb ai/A are tabulated below.

Table 3. Estimated Environmental Concentrations on Avian and Mammalian Food Items (ppm) Following a Single Application at 1 lb ai/A)

Food Items	EEC (ppm) Predicted Maximum Residue ¹	EEC (ppm) Predicted Mean Residue ¹
Short grass	240	85
Tall grass	110	36
Broadleaf/forage plants, and small insects	135	45
Fruits, pods, seeds, and large insects	15	7

¹ Predicted maximum and mean residues are for a 1 lb ai/A application rate and are based on Hoerger and Kenaga (1972) as modified by Fletcher *et al.* (1994).

Predicted residues (EECs) resulting from multiple applications are calculated in various ways. For this assessment, maximum disulfoton EECs were calculated using Hoerger and Kenaga (1972) as modified by Fletcher *et al.* (1994). These EECs served as inputs into the FATE

program. The FATE program is a first order dissipation model, i.e., the pesticide is applied repeatedly, but degrades over time from the first application to some assigned time thereafter. In the case of disulfoton the time period was 30 days. A foliar degradation half life of 3.3 days was selected based on a field monitoring study (MRID #41201801). EEC values for a variety of crops and application rates/methods are provided in the risk quotient tables in Section 4, "Ecological Risk Assessment."

D. Water Resources Assessment

i. Summary and Conclusions

This section presents the assessment of the potential of disulfoton (and degradates) to contaminate surface water and ground water from label uses. The assessment includes a Tier II estimates of environmental concentrations (EECs) of disulfoton and total disulfoton residues (TDR sum of disulfoton, D. sulfoxide, and D. sulfone) in surface water and SCI-GROW estimates of ground water concentrations, and the available monitoring data which primarily addresses only parent disulfoton. Tier I was not included because EECs levels of concern are generally exceeded for organophosphate insecticides, thus, necessitating a more refined evaluation. The ecological exposure assessment used the standard farm pond scenarios and the drinking water assessment utilized the Index Reservoir and Percent Crop Area concepts.

The Tier II modeling of disulfoton residue concentrations in surface water used the PRZM3 and EXAMS models as applied to barley, cotton, potatoes, tobacco, and spring wheat, using maximum label application rates and several application methods. Surface water monitoring data collected by the USGS as part of the National Water Quality Assessment (NAWQA) (Gilliom, 1995; USGS, 1997) program, USEPA's STORET, and any State study that measured disulfoton in surface water were also considered. The potential for disulfoton residues in ground water is assessed using the EFED ground-water concentration screening model (SCI-GROW) and the monitoring data available in EFED's Pesticides in Ground Water Data Base (PGWDB) (USEPA, 1992), USGS NAWQA study (USGS, 1997), and STORET (search date 10/16/97). The purpose of this analysis is to provide an estimate of environmental concentrations of disulfoton (and degradates) in surface water bodies and ground water for use in the human health and ecological risk assessment as part of the registration process. The environmental fate data base is not complete for disulfoton. Limited data indicates that the degradates are much more persistent and mobile than parent disulfoton. Organophosphate degradates are often as toxic as the parent compound and are considered in this assessment as total disulfoton residues (TDR). However, as noted, since data are lacking there is considerable uncertainty in these estimates.

Surface- and ground-water monitoring data available in STORET were evaluated in detail, but were generally not considered due to limitations associated with high detection limits and difficulty in interpreting the data. Detailed discussion of the STORET findings is presented in the Appendix III .

The Tier II EEC assessment uses a single site, or multiple single sites, which represents a high-end exposure scenario from pesticide use on a particular crop or non-crop use site for ecological exposure assessments. The EECs for disulfoton were generated for multiple crop scenarios using PRZM3.12 (Carsel, 1997; 5/7/98) which simulates the erosion and run-off from an

agricultural field and EXAMS 2.97.5 (Burns, 1997; 6/13/97) which simulates the fate in a surface water body. PRZM3 and EXAMS estimates for a single site, over multiple years, EECs for a 1 ha surface area, 2 m deep farm pond draining an adjacent 10 ha barley, cotton, potato, tobacco, or spring wheat field. Each scenario, or site, was simulated for 20 to 40 (depending on data availability) years. EFED estimated 1 in 10 year maximum peak, 4-day average, 21-day average, 60-day average, 90-day, annual average concentrations, and the mean of the annual averages. Disulfoton (Di-Syston) formulations were based upon registered uses on the specific crops. The application rates (maximum on label ; EPA Reg. No. 3125-172, 3125-307), numbers, and intervals are listed in Tables 7a. and 7b. and Tables 8a. and 8b. and environmental fate inputs are listed in Table 6. PRZM simulations were run using maximum application rates, maximum number of yearly applications, and the shortest recommended application interval. Spray drift is determined by method of pesticide application (and assumed to be 5% for aerial spray; 1% for ground spray, 0% for granular or soil incorporated applications) per EFED guidance for the pond scenarios (USEPA, 1999).

The PRZM/EXAMS EECs are generated for high exposure agricultural scenarios and represent one in ten year EECs in a stagnant pond with no outlet that receives pesticide loading from an adjacent 100% cropped, 100% treated field for parent disulfoton and total disulfoton residues. As such, the computer generated EECs represents conservative screening levels for ponds, lakes, and flowing water and should only be used for screening purposes. The EECs have been calculated so that in any given year, there is about a 10% probability that the maximum average concentration of that duration in that year will equal or exceed the EEC at the site. Tier II upper tenth percentile EECs for disulfoton and total disulfoton residues are presented in Tables 7a. and 7b. and 8a. and 8b. for the pond and the index reservoir with PCA adjustment, respectively.

The sites selected are currently used by EFED (standard scenarios) to represent a reasonable “at risk” soil for the region or regions being considered. The scenarios selected represent high-end exposure sites. The sites are selected so that they generate exposures larger than for most sites (about 90 percent) used for growing the selected crops. An “at risk” soil is one that has a high potential for run-off and soil erosion. Thus, these scenarios are intended to produce conservative estimates of potential disulfoton concentrations in surface water. The crop, MLRA, state, site, and soil conditions for each scenario are given in Tables 4 and 5.

The SCI-GROW (Screening Concentration in Ground Water) screening model developed in EFED (Barrett, 1997) was used to estimate potential ground water concentrations for disulfoton parent and total disulfoton residues under “generic” hydrologically vulnerable conditions. SCI-GROW provides a screening concentration, an estimate of likely ground water concentrations if the pesticide is used at the maximum allowed label rate in areas with ground water exceptionally vulnerable to contamination. In most cases, a majority of the use area will have ground water that is less vulnerable to contamination than the areas used to derive the SCI-GROW estimate.

ii. Application Rates Used in Modeling

The application rates (Tables 7a and b, 8a and 8b) selected for use in the modeling scenarios

were based upon information submitted by the registrant, analysis conducted by BEAD, and the disulfoton (Di-Syston) labels. Four factors went into selecting the application rate: 1) the range of ounces or pounds a.i.; 2) the area or length of row per acre (which is influenced by row spacing); 3) the number of applications; and 4) the application interval. The maximum rate (ounces or pounds a.i. per crop simulated) and the shortest application intervals were selected. The shorter the distance between the crop rows the greater the application rates on an area basis.

iii. Modeling Scenarios

Surface Water: The disulfoton scenarios (Tables 4 and 5) are representative of high run-off sites for barley in the Southern Piedmont of Virginia (MLRA 136), cotton in the Southern Mississippi Valley Silty Uplands of Mississippi (MLRA 134), potatoes in the New England and Eastern New York Upland of Maine (MLRA 144A), tobacco in Southern Coastal Plain of Georgia (MLRA 133A), and spring wheat in the Rolling Till Prairie of South Dakota (MLRA 102A). The scenarios chosen are professional best judgement sites expected to produce run-off greater than would be expected at 90% of the sites where the appropriate crop is grown. Soils property data (Table 5) and planting date information were obtained from the PRZM Input Collator (PIC) data bases (Bird et al, 1992). The Percent Crop Area (PCA) values used for the five scenarios for estimated drinking water concentrations are also given in Table 4.

Table 4. Crop, location, soil and hydrologic group for each modeling scenario.							
Crop	MLRA¹	State	Soil Series	Soil Texture	Hydrologic Group	Period (Years)	PCA²
Barley	136	VA	Gaston	sandy clay loam	C	27	0.87
Cotton	131 ³	MS	Loring	silt loam	C	20	0.20
Potatoes	144A	ME	Paxton	sandy loam	C	36	0.87
Tobacco	133A	GA	Emporia	loamy sand	C	36	0.87
Spr.Wheat	102A	SD	Peever	clay loam	C	40	0.56

¹MLRA is major land resource area (USDA, 1981).

² PCA is the Percent Crop Area.

³Meteorological file met131.met is used in the EFED standard cotton scenario, since the weather station is closer to the simulated site.

Table 5. Selected soil properties used modeling.					
Soil Series (MLRA)	Depth (in)	Bulk Density (g/cm³)	Organic Carbon (%)	Field Capacity (cm³/cm³)	Wilting Point (cm³/cm³)
Gaston (136)	16	1.6	1.740	0.246	0.126
	84	1.6	0.174	0.321	0.201
	50	1.6	0.116	0.222	0.122
Loring (131)	10	1.6	1.160	0.294	0.094
	10	1.6	1.160	0.294	0.094
	105	1.8	0.174	0.147	0.087
Paxton (144A)	20	1.6	2.90	0.166	0.66
	46	1.8	0.174	0.118	0.38
	34	1.8	0.116	0.085	0.035
Emporia (133A)	38	1.4	1.16	0.104	0.054
	62	1.6	0.174	0.225	0.125
	50	1.6	0.116	0.135	0.056
Peever (102A)	18	1.35	1.740	0.392	0.202
	82	1.60	0.116	0.257	0.177
	50	1.60	0.058	0.256	0.176

Ground Water: The SCI-GROW (Screening Concentration in Ground Water) screening model developed in EFED (Barrett, 1997) was used to estimate potential ground water concentrations for disulfoton parent and total disulfoton residues under “generic” hydrologically vulnerable

conditions, but necessarily the most vulnerable conditions. The SCI-GROW model is based on scaled ground water concentrations from ground water monitoring studies, environmental fate properties (aerobic soil half-lives and organic carbon partitioning coefficients-Koc's) and application rates.

iv. Modeling Procedure

Environmental fate parameters used in PRZM3 and EXAMS runs are summarized in Table 6. The standard EFED pond (mspond) was used. The PRZM3 simulations were run for a period of 36 years on potatoes, and tobacco, beginning on January 1, 1948 and ending on December 31, 1983. Barley was run for 27 years (1956-1983) and spring wheat was run for 40 years (1944-1983). Cotton was run for 20 years of data (January 1, 1964- December 31, 1983). Scenario information is summarized in Tables 4 and 5. The EXAMS loading (P2E-C1) files, a PRZM3 output, were pre-processed using the EXAMSBAT post-processor. EXAMS was run for the 20-40 years using Mode 3 (defines environmental and chemical pulse time steps). For each year simulated, the annual maximum peak, 96-hour, 21-day, 60-day, 90-day values, and annual means in addition to the mean of annual means were extracted from the EXAMS output file REPORT.XMS with the TABLE20 post-processor. The 10 year return EECs (or 10% yearly Exceedence EECs) listed in Tables 7a., 7b., 8a. and 8b. were calculated by linear interpolation between the third and fourth largest values by the program TABLE20.

Table 6. Disulfoton fate properties and values used in (PRZM3/EXAMS) modeling.		
Parameter	Value	Source
Molecular Weight	274.39	MRID 150088
Water Solubility	15 mg/l @20	MRID 150088
Henry's Law Coefficient	2.60 atm-m ³ /mol	EFED One-liner 05/21/97
Partition Coefficient (Koc)	551.5 (mean of 4)	MRID 43042500
Vapor Pressure	1.8E-04 mmHg	EFED One-liner 05/21/97
Hydrolysis Half-lives @ pH 4 pH 7 pH 9	1174 days 323 " 231 "	MRID 143405
Hydrolysis Rate Constants (needed for EXAMS derived from Hydrolysis half-lives)	Kah = (negative) Knh = 8.88E-05 Kbh = 3.58	
Aerobic Soil Half-life (Disulfoton)	6.12 days (0.113/d)	Upper 90% confidence bound on the mean of "half-lives" for the two aerobic soils tested in the laboratory. MRIDs 40042201, 41585101, 43800101
Aerobic Soil Half-life ¹ (Total Disulfoton Residues)	259.63 days (2.67E-03/d)	Upper 90% confidence bound on the mean of half-lives for the two aerobic soils tested in the laboratory. MRIDs 40042201, 41585101, 43800101
Water Photolysis	3.87 days (pH = 5) (0.179/d)	MRID 40471102
Aerobic Aquatic Half-life (Disulfoton) (Kbaws, Kbacs)	12.2 days (0.05682/day)	Estimated per EFED guidance
Aerobic Aquatic Half-life (Total Disulfoton Residues) (Kbaws, Kbacs)	259.63 days (2.67E-03/d)	Did not multiple half-life by 2 per EFED guidance to account for uncertainty. Half-lives greater than a year would show residue accumulation.
Foliar Dissipation Rate	3.3 days (0.21/d)	MRID 41201801

¹ Half-lives for total residues were determined from the total residues at each sampling interval. Total disulfoton residues did follow first-order kinetic decay (The slope (decay rate constant, k) of the transformed (natural log or ln) ($\ln C(t) = \ln C_0 - kt$, where C_0 is the initial concentration, C is concentration, and t is time)).

v. Modeling Results

a. Surface water

In the Tier II assessment, the mean of the annual mean concentrations of disulfoton (Table 7a) in a farm pond over multiple years simulated ranged from 0.21 µg/L for a two applications (@0.83 lb ai/a) to barley in Virginia to 1.14 µg/L for potatoes in Maine with the three applications at the maximum application rate (@1.00 lb ai/ac). The one-in-ten year maximum, or peak, estimated concentrations of 26.75 µg/L occurred for one 4.0 lb. ai/ac applications of disulfoton to tobacco in Georgia. For the other scenarios or recommended application rates, the maximum concentrations ranged from 7.14 to 18.46 µg/L. Because of limited data, the modeling results, therefore, cannot be confirmed by the monitoring data.

Because the degradates of disulfoton (including oxygen analogs): sulfoxide and sulfone are also toxic, the EECs of the total disulfoton residue (TDR) in a farm pond was also considered (Table 7b). The overall estimated of the multiple year mean concentrations of TDR in a farm pond over multiple years simulated ranged from 3.89 µg/L for two applications at the maximum rate (1.00 lb ai/A) to barley in Virginia to 9.32 µg/L for tobacco in Georgia with one application at the maximum application rate (4.00 lb ai/A). Maximum, or peak, estimated TDR concentrations of 58.47 µg/L occurred for one 4.00 lb. ai/ac application of disulfoton to tobacco. For the other scenarios, the maximum TDR concentrations ranged from 15.32 to 52.93 µg/L. There are no monitoring data to evaluate these concentration estimates from PRZM/EXAMS modeling. Water samples collected, following a fish kill incident in Colorado, contained disulfoton sulfoxide at levels of 29.5-48.7 µg/L, and disulfoton sulfone at 0.0199-0.214 µg/L. The source of the disulfoton was Di-Syston E.C. applied to wheat which was followed by heavy rain fall.(Incident Report No. I001167-001).

The PRZM/EXAMS estimated disulfoton residue concentrations in surface water appear to be strongly related to the application rate, number of applications, application interval, and method of application and timing to application to rainfall events.

Table 7a. Tier II Upper Tenth Percentile EECs for Disulfoton Parent Used on barley, cotton, potatoes, tobacco, and spring wheat for several application (Label maximum) rates and management scenarios estimated using PRZM3/EXAMS in standard farm pond.								
Crop	Disulfoton Application	Concentration (µg/L) (1-in-10 annual yearly maximum value)						Mean of Annual Means (µg/L)
	Rate/Number of Apps/Interval/Incorp. Depth/method¹							
	lb.ai/A/ #/ days/ inches	Peak	96-Hour Avg.	21-Day Avg.	60-Day Avg.	90-Day Avg.	Annual Avg.	
Barley	1.0 /2/21/0/f	9.20	7.93	5.96	3.79	2.82	0.79	0.50
Barley	0.83/2/21/0/s (granular)	7.14	6.32	4.36	2.37	1.73	0.49	0.21
Cotton	1.0 /3/21/0/s	14.79	12.96	8.05	4.91	3.44	0.92	0.48
Potatoes	4.0 /2/14/2.5/s	7.14	6.40	4.51	2.59	1.80	0.44	0.33
Potatoes	1.0/3/14/0/f	15.02	13.24	10.40	6.89	4.89	1.23	1.14
Tobacco	4.0/1/0/2.5/s (granular)	26.75	24.33	17.89	9.94	6.87	1.72	0.66
Tobacco	4.0/1/0/2.5/s	18.46	16.79	12.54	6.74	4.64	1.15	0.42
Spr.Wheat	0.75/2/30/0/f	8.90	7.95	5.47	3.81	2.76	0.73	0.66

¹ Method of application: f = foliar and s = soil

Table 7b. Tier II Upper Tenth Percentile EECs for Total Disulfoton Residues Used on barley, cotton, potatoes, tobacco, and spring wheat for several application (Label maximum) rates and management scenarios estimated using PRZM3/EXAMS in standard farm pond.								
Crop	Disulfoton Application	Concentration (µg/L) (1-in-10 annual yearly maximum value)						Mean of Annual Means (µg/L)
	Rate/Numberof Apps/Interval/Incorp. Depth/method¹							
	lb.ai/A/ #/ days/ inches	Peak	96-Hour Avg.	21-Day Avg.	60-Day Avg.	90-Day Avg.	Annual Avg.	
Barley	1.0 /2/21/0/f	21.77	20.99	19.27	17.35	16.48	7.51	4.94
Barley	0.83/2/21/0/s (granular)	19.95	19.34	17.44	15.02	14.46	6.60	3.89
Cotton	1.0 /3/21/0/s	44.78	43.50	39.27	34.37	32.41	15.61	9.13
Potatoes	4.0 /2/14/2.5/s	15.43	14.94	13.51	12.20	10.97	6.02	4.48
Potatoes	1.0/3/14/0/f	27.36	26.59	23.92	20.88	19.33	9.75	8.37
Tobacco	4.0/1/0/2.5/s (granular)	58.47	56.35	49.54	39.57	35.30	15.23	9.32
Tobacco	4.0/1/0/2.5/s	52.93	51.03	44.76	35.68	31.94	13.36	7.16
Spr.Wheat	0.75/2/30/0/f	16.92	16.36	14.91	12.56	11.29	5.65	4.73

¹ Method of application: f = foliar and s = soil

Surface Water Drinking Water Assessment with Index Reservoir and Percent Crop Area

The estimated drinking water concentrations (EDWCs) were evaluated using the methodology outlined in EPA-OPP *draft* Guidance for Use of the Index Reservoir and Percent Crop Area Factor in Drinking Water Exposure Assessments (USEPA, 2000). This generally results in the modification of the scenarios developed for farm ponds to scenarios for the index reservoirs.

The purpose the Index Reservoir (IR) scenario and the Percent Crop Area (PCA) for use in estimating the exposure in drinking water derived from vulnerable surface water supplies. Since the passage of the Food Quality Protection Act (FQPA) in 1997, the Agency has been using the standard farm pond as an interim scenario for drinking water exposure and has been assuming that 100% of this small watershed is planted in a single crop. The Agency is now implementing the index reservoir to represent a watershed prone to generating high pesticide concentrations that is capable of supporting a drinking water facility in conjunction with the percent cropped area (PCA) which accounts for the fact that a watershed large enough to support a drinking water facility will not usually be planted completely to a single crop. These two steps are intended to improve the quality and accuracy of the drinking water exposure for pesticides obtained by models.

Percent Crop Area (PCA): PCA is a generic watershed-based adjustment factor that will be applied to pesticide concentrations estimated for the surface water component of the drinking water exposure assessment using PRZM/EXAMS with the index reservoir scenario. The output generated by the linked PRZM/EXAMS models is multiplied by the maximum percent of crop area (PCA) in any watershed (expressed as a decimal) generated for the crop or crops of interest. Currently, OPP has PCA adjustments for four major crops – corn, cotton, soybeans, and wheat. Two are appropriate for disulfoton, cotton and wheat.

The concept of a factor to adjust the concentrations reported from modeling to account for land use was first proposed in a presentation to the SAP in December 1997 (Jones and Abel, 1997). This guidance results from a May 1999 presentation to the FIFRA Scientific Advisory Panel (SAP), *Proposed Methods For Determining Watershed-derived Percent Crop Areas And Considerations For Applying Crop Area Adjustments to Surface Water Screening Models*, and the response and recommendations from the panel. A more thorough discussion of this method and comparisons of monitoring and modeling results for selected pesticide/crop/site combinations is located at: http://www.epa.gov/scipoly/sap/1999/may/pca_sap.pdf.

The Agency will continue to develop PCAs for other major crops in the same manner as was described in the May 1999 SAP presentation. However, the Agency expects that it will use smaller watersheds for these calculations in the near future. For minor-use crops, the SAP found that the use of PCAs produced less than satisfactory results and advised OPP to further investigate possible sources of error. Thus, for the near term, OPP is not be using PCAs in a crop-specific manner for both major crops that do not yet have PCAs and minor-use crops. Instead it will use a default PCA that reflects the total agricultural land in an 8-digit Hydrologic Unit Code (HUC). The PCA values used in this assessment are listed in Appendix VII.

The OPP guidance document provides information on when and how to apply the PCA to model estimates, describes the methods used to derive the PCA, discusses some of the assumptions and limitations with the process, and spells out the next steps in expanding the PCA implementation beyond the initial crops. Instructions for using the index reservoir and PCA are provided below. Discussion on some of the assumptions and limitations for both the PCA and Index Reservoir are included in the Reporting section. One should note that there is an entry for ‘All Agricultural Land’ in Appendix VII. This is a default value to use for crops for which no specific PCA is available. It represents the largest amount of land in agricultural production in any 8-digit hydrologic unit code (HUC) watershed in the continental United States.

The unadjusted EDWC (PRZM/EXAMS output) is multiplied by the appropriate PCA for that crop to obtain the final estimated drinking water concentration (EDWC). Note that if Tier 2 modeling is done for an area other than the standard scenario, the PCA would still be applied, since it represents the maximum percent crop area for that particular crop. (As regional modeling efforts are expanded, regional PCAs could be developed in the future.) As an example, for a pesticide used only on cotton, the PRZM/EXAMS estimated environmental concentrations would be multiplied by 0.20. This factor would be applied to the standard PRZM/EXAMS scenario for cotton or any non-standard cotton scenario until such time as regional PCAs are developed.

When multiple crops occur in the watershed, the co-occurrence of these crops needs to be considered. The PCA approach assumes that the adjustment factor represents the maximum potential percentage of a watershed that could be planted to a crop. If, for example, a pesticide is only used on cotton, then the assumption that no more than 20% of the watershed (at the current HUC scale used) would be planted to the crop is likely to hold true.

The Index Reservoir (IR): IR is intended as a drop-in replacement for the standard pond for use in drinking water exposure assessment. It is used in a manner similar to the standard pond, except that flow rates have been modified to reflect local weather conditions. The PRZM and EXAMS input files for the standard pond and index reservoir are in Appendix IX. This guidance results from a July, 1998 presentation to the FIFRA Science Advisory Panel. The materials for that presentation are at: <http://www.epa.gov/scipoly/sap/1998/index.htm>

Barley, cotton, potatoes, tobacco, and spring were considered because they represent significant uses, maximum application rates, and are grown in vulnerable regions of the United States. For the PRZM, the input files for each IR scenario are essentially the same as its farm pond scenario. Three parameters in the PRZM input file require modification, AFIELD, HL, and DRFT. These changes are shown in Appendix VIII.

The estimated drinking water concentrations using the Index Reservoir (IR) and PCA (PCA) concepts for the same scenarios used for ecological exposure assessments were evaluated (Tables 8a and 8b). The long term mean of the parent disulfoton concentration in the Index Reservoir and by PCA ranged from 0.23 to 1.31 µg/L for cotton and tobacco, respectively. The 1-in-10 year estimated annual mean concentration ranged from 0.43 to 2.77 µg/L for cotton and tobacco, respectively. The peak 1-in-10 year estimated drinking water concentration for parent

disulfoton ranged from 7.13 to 44.20 µg/L.

The Tier II modeling results from PRZM/EXAMS fall within the range of concentrations for surface water reported in the STORET database (0.0 to 100 µg/L, 96 percent of 8137 samples were reported as less than 16 µg/L), a Virginia monitoring study (0.37 to 6.11 µg/L) and NAWQA (0.010 to 0.060 µg/L). But because some of the data in STORET have a high degree of uncertainty because many samples were only listed as “actual value is known to less than given value”, the maximum concentration of samples was not always known (see Appendix III). The modeled concentration estimates are generally greater than those seen in the monitoring data. The modeling results therefore cannot be confirmed by the monitoring data.

Because the degradates of disulfoton (including oxygen analogs): sulfoxide and sulfone are also toxic, the EECs of the total disulfoton residue (TDR) in the index reservoirs was also considered. The long term mean of the total disulfoton residues (TDR) in the Index Reservoir and by PCA ranged from 2.55 to 10.42 µg/L for cotton and potatoes, respectively. The 1-in-10 year estimated annual mean TDR concentrations in the IR ranged from 5.10 to 16.72 µg/L for cotton and potatoes, respectively. The peak 1-in-10 year estimated TDR concentrations in the IR ranged from 20.83 to 104.92 µg/L. There are no monitoring data to evaluate these concentration estimates from PRZM/EXAMS modeling.

Uncertainty surrounds these estimates because the sites selected for modeling represent sites thought to be representative of vulnerable sites. Additionally, the IR was generic (to each scenario) and data to fully understand of the fate of disulfoton and disulfoton residues is not available. Evidence suggests that the concentrations will not be as high as suggest by the modeled estimates. The PCA values have been estimated by OPP for spring wheat (0.56) and cotton (0.20). The default for value for all agricultural land of 0.87 was used for the barley, potatoes, and tobacco scenarios. Better estimates of the PCA for these crops would reduce the uncertainty associated with the estimated drinking water concentrations.

Table 8a. Tier II Upper Tenth Percentile EECs for Disulfoton Parent Used on barley, cotton, potatoes, tobacco, and spring wheat for several application (Label maximum) rates and management scenarios estimated using PRZM3/EXAMS in Index Reservoir with Percent Crop Area.

Crop ²	Disulfoton Application	Concentration (µg/L) (1-in-10 annual yearly maximum value)						Mean of Annual Means (µg/L)
	Rate/Number of Apps/Interval/Incorp. Depth/method ¹							
	lb.ai/A/ #/ days/ inches	Peak	96-Hour Avg.	21-Day Avg.	60-Day Avg.	90-Day Avg.	Annual Avg.	
Barley	1.0 /2/21/0/f	15.51	14.18	11.67	7.69	6.09	1.61	0.95
Barley	0.83/2/21/0/s (granular)	14.88	13.57	9.82	5.59	4.16	1.22	0.51
Cotton	1.0 /3/21/0/s	7.13	6.24	3.86	2.32	1.61	0.43	0.23
Potatoes	4.0 /2/14/2.5/s	18.83	17.17	12.73	7.53	5.22	1.30	1.05
Potatoes	1.0/3/14/0/f	13.09	11.77	9.59	6.19	4.38	1.09	0.94
Tobacco	4.0/1/0/2.5/s (granular)	44.20	40.39	30.14	16.23	11.14	2.77	1.31
Tobacco	4.0/1/0/2.5/s	38.57	35.24	26.56	14.09	9.62	2.38	0.86
Spr.Wheat	0.75/2/30/0/f	6.32	5.76	3.88	2.41	1.79	0.48	0.38

¹ Method of application: f = foliar and s = soil

² PCA Barley, Potatoes, Tobacco = 0.87 (default value for all ag. land); cotton = 0.20, Spring wheat = 0.56

Table 8b. Tier II Upper Tenth Percentile EECs for Total Disulfoton Residues Used on barley, cotton, potatoes, tobacco, and spring wheat for several application (Label maximum) rates and management scenarios estimated using PRZM3/EXAMS with Index Reservoir and Percent Crop Area.

Crop ²	Disulfoton Application	Concentration (µg/L) (1-in-10 annual yearly maximum value)						Mean of Annual Means (µg/L)
	Rate/Numberof Apps/Interval/Incorp. Depth/method ¹							
	lb.ai/A/ #/ days/ inches	Peak	96-Hour Avg.	21-Day Avg.	60-Day Avg.	90-Day Avg.	Annual Avg.	
Barley	1.0 /2/21/0/f	34.53	33.30	29.47	22.33	18.04	7.62	4.21
Barley	0.83/2/21/0/s (granular)	39.05	37.64	32.50	27.99	26.30	10.01	5.42
Cotton	1.0 /3/21/0/s	20.83	20.22	17.91	14.10	12.82	5.10	2.55
Potatoes	4.0 /2/14/2.5/s	36.57	35.64	32.41	30.06	26.91	13.44	10.42
Potatoes	1.0/3/14/0/f	34.37	33.56	30.21	27.87	25.85	16.72	9.49
Tobacco	4.0/1/0/2.5/s (granular)	104.92	100.31	85.43	66.65	53.36	16.25	8.70
Tobacco	4.0/1/0/2.5/s	103.79	99.44	85.04	63.97	5347.00	15.99	8.01
Spr.Wheat	0.75/2/30/0/f	15.48	15.09	13.84	12.24	11.03	4.88	3.68

¹ Method of application: f = foliar and s = soil

² PCA values for Barley, Potatoes, Tobacco = 0.87 (default value); cotton = 0.20, Spring wheat = 0.56

b. Ground water

For this assessment, the maximum rate and number of disulfoton applications were used, while assuming conservative environmental properties (90 percent upper confidence bound on the mean aerobic soil half-life of 6.12 days and an average K_{oc} value of 551 mL/g). The maximum disulfoton concentration predicted in ground water by the SCI-GROW model (using the maximum rate 4 lb. a.i./ac and 2 applications - potatoes) was 0.05 µg/L. The maximum total disulfoton residue concentration predicted in ground water by the SCI-GROW model for the same scenario is 3.19 µg/L (except 90 percent upper bound on mean half-life of total residues is 259.6 days).

It should be noted that all the detections of disulfoton residues in ground water in Wisconsin (range 4.0 to 100.0 µg/L) and some detections in Virginia (range 0.04 -2.87 µg/L) exceeded the concentrations predicted by SCI-GROW (0.05 µg/L). Although SCI-GROW, which is thought to be conservative (e.g., a vulnerable site), is based on a regression relationship between monitoring data (detected concentrations) and pesticide fate chemistry at vulnerable sites, SCI-GROW does not account for preferential flow, point-source contamination, pesticide spills, misuses, or pesticide storage sites. Many unknowns, data limitations, such as on-site variability, are also present in the prospective ground-water monitoring studies which were not included when developing SCI-GROW. The difference between monitoring and modeling is discussed further in the next section.

vi. Disulfoton Monitoring Data

Ground Water:

Monitoring Studies With No Disulfoton Residues Detections in Ground Water: The Pesticides in Ground Water Data Base (USEPA, 1992) summarizes the results of a number of ground-water monitoring studies conducted which included disulfoton (and rarely the disulfoton degradates D. sulfone and D. sulfoxide). Monitoring, with no detections (limits of detections ranged from 0.01 to 6.0 µg/L), has occurred in the following states (number of wells): AL (10), CA (974), GA (76), HI (5), IN (161), ME (71), MS (120), MN (754), OK (1), OR (70), and TX (188). The range of detection limits, especially the high ones (e.g., 6 µg/L) reduce the certainty of these data.

One hundred twenty wells were analyzed in MS for disulfoton degradates sulfone and sulfoxide and 188 wells were analyzed in TX for sulfone. Limits of detection were 3.80 and 1.90 µg/L for the sulfone and sulfoxide degrade, respectively, in MS. There were no degradates reported in these samples.

North Carolina: The North Carolina Departments of Agriculture (NCDA) and Environment, Health, and Natural Resources (DEHNR) conducted a cooperative study under the direction of the North Carolina Pesticide Board (NCIWP, 1997). The purpose of the statewide study was to determine if the labeled uses of pesticide products were impacting the ground water resources in North Carolina.

The study was conducted in two phases. In phase one, 55 wells in the DEHNR Ground Water

Section's ambient monitoring network representing the major drinking water aquifers of the state were sampled at least twice and analyzed for selected pesticides. In phase two, 97 cooperator monitoring wells were installed and subsequently sampled at least twice in 36 counties across the North Carolina. Sites for the cooperator monitoring wells were chosen based on an evaluation of the vulnerability of ground water to risk of contamination from the use of pesticides.

Monitoring wells were located adjacent to and down-gradient from areas where pesticides were reported to have been applied (within 300 feet) during the previous five years. Wells were constructed so that the shallowest ground water could be collected for analysis. The objective of these criteria was to use a scientific method for determining monitoring well locations so that the results could be used as an early indication of the potential for problems associated with pesticides leaching to ground water. Disulfoton residues were monitored for in five North Carolina counties, Alleghany, Ash, Beaufort, Madison, and Robeson. Seven wells were located in Christmas Tree growing areas, one in wheat growing county, and two in tobacco areas. The study authors make the following statement, *"Results cannot be interpreted as representing the quality of ground water near pesticide use areas statewide because the study methods targeted areas of highly vulnerable ground water"*.

There were no detections of disulfoton, disulfoton sulfoxide, and disulfoton in the ground- water monitoring study conducted in North Carolina. Efforts were made to place the wells in vulnerable areas where the pesticide use was known, so that the pesticide analyzed for would reflect the use history around the well. Limitations of the study include that sites were sampled only twice and the limits of detections were high (e.g., $> 1.0 \mu\text{g/L}$) for some of disulfoton analytes. Uncertainties associated with the study include whether two samples from eight wells are adequate to represent the ground-water concentrations of disulfoton residues, did DRASTIC correctly identify a site's vulnerability, and were the wells placed down-gradient of the use areas.

The study used tools and information available at the time of the study to identify vulnerable locations for well placement. This included statewide agricultural data from the N.C. Agricultural Statistics which were used to identify crop growing areas, the USEPA DRASTIC method (Aller et al., 1987) was used to locate the most vulnerable locations in the target crop growing areas, and local county agents of the USDA Natural Resources Conservation Service (NRCS) helped identify cooperators-farmers for placement of wells. The Pesticide Study staff and county agents also met with the cooperators to obtain pesticide use information. Other studies have shown that DRASTIC is not as good a method to identify vulnerable areas as hoped. The study appeared to QA/QC practices.

Monitoring Studies With Disulfoton Detections in Ground Water: Two of the studies cited in the PGWDB (USEPA, 1992) report the detection of disulfoton residues in ground water. The disulfoton detections in ground water in occurred studies conducted by Virginia Polytechnic Institute and State University (VPI&SU, Mosaghimi, 1989) in Virginia where disulfoton concentrations ranged from 0.04 to $2.87 \mu\text{g/L}$ and in a Wisconsin Department of Natural Resources study in Wisconsin (WDNR, after Barton, 1982) where concentrations ranged from 4.00 to $100.00 \mu\text{g/L}$. Of specific are the disulfoton concentrations of parent disulfoton reported in these studies (VA and WI) that exceeded the estimate of $0.05 \mu\text{g/L}$ obtained from EFED's

SCI-GROW (ground-water screening model) model.

Virginia: A monitoring study was conducted to evaluate the effectiveness of Best Management Practices (BMP) in a 3616-acre watershed in the Nomini Creek Watershed, Westmoreland County, Virginia. Approximately half of the watershed is in agriculture and the other half is forested. The major focus of this study was surface-water quality rather than ground-water quality. However, in addition to the surface-water monitoring, twelve wells were analyzed for pesticides, including disulfoton.

Samples were taken in 1985 and 1986 from four household wells in the Nomini Creek Watershed (NCW). Water samples from these wells were analyzed for 24 pesticides. Detectable levels of (not specified) pesticides were found in all four wells at concentrations below the respective MCL. One of these four household wells consistently had higher pesticide levels than the other wells. The study authors suggested that this household well was not "sufficiently protected and was contaminated by surface runoff from adjacent land".

Based upon these results of the four household wells sampled, eight pairs of ground-water monitoring wells (39 to 54 feet deep) were installed at eight sites in the NCW and sampled approximately monthly from June 1986 through December 1990. Information concerning farming practices in the watershed was obtained from farmer interviews and questionnaires. Disulfoton residues (0.04, 0.10, 0.10, 0.13, 0.16, and 2.87 µg/L) were detected in wells at five of the eight monitoring sites during the period 11/86 to 12/90. The average detection was 0.57 µg/L (standard deviation = 1.13 µg/L). Since the study authors present no information or discussion questioning the pesticide detections which occurred in the monitoring wells (notably site GN3, the well with 2.87 µg/L), the disulfoton detections found in the monitoring wells should be included in this assessment.

Table 9. Summary of Disulfoton Detections in ground water from the eight ground-water monitoring wells in Nomini Creek Watershed (Virginia), during 1986 and 1987.

Sampling Date	Well-Site Number	Concentration (µg/L)
11/5/86	GN3	2.87
11/5/86	GN6	0.04
3/13/87	GN4	0.10
8/20/87	GN1	0.13
8/20/87	GN2	0.16
8/20/87	GN3	0.10

The study was conducted under a Quality Assurance/Quality Control Plan. Pesticides were determined using GLC methods with an EC Ni63 detector. The study reportedly ran until 1995 (data available only goes through 1990).

Wisconsin: Barton, 1982. In May and June 1982, the Wisconsin Department of Natural Resources (WDNR) sent twenty-nine water samples from wells in the Central Sands area of Wisconsin to the EPA's Office of Pesticide Programs for pesticide residue analysis. Samples were taken from one municipal well, two or three community wells, and twenty-five home wells; all of which were sources of drinking water. Of the 29 samples, 15 samples were reported as no detects whereas 14 samples were reported disulfoton detections. Disulfoton detections ranged from 4.00 to 100.00 µg/L, with a mean (samples with detections) of 38.43 µg/L and standard deviation of 31.56 µg/L. No detection limit was specified for disulfoton, although detections as low as 1 µg/L are reported for other pesticide residues (aldicarb, and aldicarb sulfone, dinoseb, sensor, linuron, carbofuran, and Lasso/Bravo).

Holden (1986) wrote that the WDNR sampling program was criticized for a number of reasons including that the quality assurance and quality control procedures (QA/QC) were not always followed during some stages of sampling and analysis (Holden, 1986). Holden (1986) further indicates that "Harkin et al. (1984) noted in their WIS WRC report *Pesticides in Groundwater beneath the Central Sand Plain of Wisconsin* that some detections of pesticides in initial screening were false positives and were not supported by resampling and reanalysis by more sensitive analytical methods."

Aldicarb and aldicarb sulfone were also found in this study and in follow up studies, while disulfoton was apparently not found in follow-up sampling. Aldicarb is no longer registered for use in Wisconsin.

The criticisms of the WDNR study must, however, be put in some sort of perspective. First, a study that did not follow QA/QC criteria does not and should not automatically mean that the data is bad or wrong, the detections may be correct (presence and magnitude). Frequently "older" monitoring studies often had problems associated with them, such as QA/QC problems, limited pesticide usage information, and no knowledge about the study area's hydrology. Frequently, studies with QA/QC programs are poorly designed, so that the results may be meaningless.

Pesticide residues not being found in follow-up sampling may be the result of dissipation processes and should not be used to discount detections in earlier samples. The environmental fate properties and site hydrology must also be considered. Because ground water is a dynamic system, pesticides may be present at one sampling event and not at another. So when the sample is collected, in relationship to pesticide use and rainfall, is important. All that can be said is that residues were not found in follow-up samples. It is unknown which samples were re-analyzed with more sensitive methods.

The disulfoton detections in the Central Sand Plain may have been the result of preferential flow and transport processes. Literature documents preferential flow in the Central Sand Plain. Thus,

disulfoton residues may have by-passed the soil matrix and gone directly to ground water which is possibly reflected in the "high" level of the detections. Although preferential flow is currently an ongoing area of research and much remains unknown, it is known that preferential flow is influenced by a number of factors, including rainfall amounts, intensity, and frequency. Disulfoton generally appears to be not very persistent under aerobic soil conditions and therefore may also not be very persistent in aquifers that are aerobic. Therefore it may have also been missed by utilizing a predetermined sampling schedule (e.g., monthly). Whereas a persistent chemical, such as aldicarb and aldicarb sulfone, will be found at greater frequencies and be less dependent upon timing of sampling. Disulfoton usage history before the detections and prior to the follow-up sampling is not specified.

Surface Water: A monitoring study was conducted to evaluate the effectiveness of Best Management Practices (BMP) in a 3616-acre watershed in the Nomini Creek Watershed, Westmoreland County, Virginia. Approximately half of the watershed is in agriculture and the other half is forested. The major focus of this study was surface-water quality rather than ground-water quality. The detections of parent disulfoton in surface-water samples (0.037 to 6.11 µg/L) collected (Table 10) in the Nomini Creek Watershed study fell within an order of magnitude with the estimated environmental concentrations (EECs) obtained from the PRZM/EXAMS models for parent disulfoton which range from 0.21 to 1.14 µg/L for annual mean daily concentrations and 7.14 to 26.75 µg/L for peak daily values.

Table 10. Disulfoton detections in Surface Water samples collected in the Nomini Creek Watershed (Virginia), during 1986.		
Sample date	Site Number: Sample #	Concentration (µg/L)
8/18/86	QN1:1 (9:13 am)	6.11
8/18/86	QN1:2 (12:25 pm)	0.37
9/28/86	QN2: (only 1 sample)	1.62

NAWQA: Disulfoton residues have been detected in surface water at a low frequency in the USGS NAWQA study. The percentage of detections with disulfoton concentrations >0.01 µg/L for all samples, agricultural streams, urban streams were 0.27%, 0.20, and 0.61%, respectively. The corresponding maximum concentrations were 0.060, 0.035, and 0.037 µg/L. Disulfoton has not been detected in ground water in the NAWQA study. Although pesticide usage data is collected for the different NAWQA study units, the studies are not targeted, specifically for disulfoton.

STORET: About 50 percent of the well samples reported in STORET had low levels ($<1\text{ }\mu\text{g/L}$) of disulfoton residues. However, there were indications of some high concentrations (the other 50% were reported as $<250\mu\text{g/L}$), which may be a reflection of how the data were reported as the disulfoton concentrations in the monitoring were not always known. This is because the detection limit was extremely high or not specified, and/or the limit of quantification was not stated or extremely high. Disulfoton concentrations were simply given as less than a value. Therefore, considerable uncertainty exists with respect to the STORET monitoring data.

Limitations of Monitoring Data

The interpretation of the monitoring data is limited by the lack of correlation between sampling dates and the use patterns of the pesticide within the study's drainage basin. Additionally, the sample locations were not associated with actual drinking water intakes for surface water nor were the monitored wells associated with known ground water drinking water sources. Also, due to many different analytical detection limits, no specified detection limits, or extremely high detection limits, a detailed interpretation of the monitoring data is not always possible. Limitations for the monitoring studies include the use of different limits of detection between studies, lack of information concerning disulfoton use around sampling sites, and lack of data concerning the hydro geology of the study sites. The spatial and temporal relationship between disulfoton use, rainfall/runoff events and the location and time of sampling cannot often be adequately determined. Thus, it is not always possible to judge the significance of the level or the lack of detections.

Although no assessment can be made for degradates due to lack of data, limited data suggests that the degradates are more persistent (>200 days) than disulfoton, suggesting their presence in water for a longer period of time than the parent. The degradates also appear to be more mobile than the parent compound.

vii. Limitations of this Modeling Analysis

There are number of factors which limit the accuracy and precision of this modeling analysis including the selection of the high-end exposure scenarios and maximum number of applications and rates, the quality of the data, the ability of the model to represent the real world, and the number of years that were modeled. There are additional limitations on the use of these numbers as an estimate of drinking water exposure. Individual degradation/metabolism products were also not considered due to lack of data. Another major uncertainty in the current EXAMS simulations is that the aquatic degradation rate used an estimated rate due to lack of data. Direct aquatic photolysis was also included. The total disulfoton residue decline rate was estimated from data, but K_{oc} s and hydrolysis rates for D. sulfoxide and sulfone were not known and assumed to be equal to those of parent disulfoton. These limitations influence the estimates of pesticides transported off the field (loading files) to the pond, plus the degradation once in the pond.

Spray is determined by method of pesticide application, and is assumed to be 0% percent when applied as broadcast (granular) or in-furrow, 5% for ground spray, and 15% for aerial spray for

the farm pond, and 6.4% ground and 16.4% aerial spray for the Index Reservoir scenario (Jones et al., 2000).

Tier II scenarios are also ones that are likely to produce high concentrations in aquatic environments. The scenarios were intended to represent sites that actually exist and are likely to be treated with a pesticide. These sites should be extreme enough to provide a conservative estimates of the EEC, but not so extreme that the model cannot properly simulate the fate and transport processes at the site. The EECs in this analysis are accurate only to the extent that the sites represent the hypothetical high exposure sites. The most limiting aspect of the site selection is the use of the “standard pond” which has no outlet. It also should be noted that the standard pond scenario used here would be expected to generate higher EECs than most water bodies, although, some water bodies would likely have higher concentrations (e.g., a shallow water bodies near agriculture fields that receive direct run-off from the treated field).

The quality of the analysis is also directly related to the quality of the chemical and fate parameters available for disulfoton. Acceptable data are available, but rather limited. Data were not available for degradates and the aquatic aerobic metabolism rate was not known, but estimated. Degradates with greater persistence and greater mobility would be expected to have a higher likelihood of leaching to ground water, with greater concentrations in surface water. The measured aerobic soil metabolism data is limited, but has sufficient sample size to establish an upper 90% confidence bound on the mean of half-lives for the three aerobic soils tested in the laboratory (and submitted to EFED) and reported in the EFED One-liner Database (MRIDs 40042201, 41585101, 43800101). The use of the 90%-upper bound value may be sufficient to capture the probable estimated environmental concentration when limited data are available. PRZM assumes pesticide decline follows first-order kinetics. As discussed in the aerobic soil metabolism section, disulfoton doesn't entirely follow first-order kinetics.

The models themselves represent a limitation on the analysis quality. These models were not specifically developed to estimate environmental exposure in drinking water so they may have limitations in their ability to estimate drinking water concentrations. Aerial spray drift reaching the pond is estimated from Spray Drift Task Force (SDTF) preliminary data to be 15 percent of the application rate and for ground spray it is 1 percent of the application rate. No drift was assumed for broadcast or in-furrow applications. Another limitation is the lack of field data to validate the predicted pesticide run-off. Although, several of the algorithms (volume of run-off water, eroded sediment mass) are somewhat validated and understood, the estimates of pesticide transport by PRZM3 has not yet been fully validated. Other limitations of PRZM are the inability to handle within site variation (spatial variability), crop growth, and the overly simple water balance. Another limitation is that 20 to 40 years of weather data were available for the analysis. Consequently there is a 1 in 20, 27, 36, or 40 chance that the true 10% exceedence EECs are larger than the maximum EEC in the analysis. If the number of years of weather data were increased, it would increase the level of confidence that the estimated value for the 10% exceedence EEC was close to the true value.

EXAMS is primarily limited because it is a steady-state model and cannot accurately characterize the dynamic nature of water flow. A model with dynamic hydrology would more

accurately reflect concentration changes due pond overflow and evaporation. Thus, the estimates derived from the current model simulates a pond having no-outlets, flowing water, or turnover. Another major limitation in the current EXAMS simulations is that the aquatic (microbial) and abiotic degradation pathways were adequately considered. The binding potential of the degradates is not known and was not considered.

Another important limitation of the Tier II EECs for drinking water exposure estimates is the use of a single 10-hectare drainage basin with a 1-hectare pond. It is unlikely that this small system accurately represents the dynamics in a watershed large enough to support a drinking water utility. It is unlikely that an entire basin, with an adequate size to support a drinking water utility would be planted completely in a single crop or be represented by scenario being modeled. The pesticides would more likely be applied over several days to weeks rather than on a single day. This would reduce the magnitude of the conservative concentration peaks, but also make them broader, reducing the acute exposure, but perhaps increasing the chronic exposure.

3. Ecological Effects Hazard Assessment

A. Toxicity to Terrestrial Animals

i. Birds, Acute and Subacute

An acute oral toxicity study using the technical grade of the active ingredient is required to establish the toxicity of a pesticide to birds. The preferred test species is either mallard duck or bobwhite quail. Results of this test are tabulated below. Acute oral testing was also performed with the 15G formulation of disulfoton. Additionally, acute oral testing was required for the two major degradation products of disulfoton, disulfoton sulfone and disulfoton sulfoxide, due to their relative persistence. These test results are as follows:

Table 11. Avian Acute Oral Toxicity

Species	% ai	LD50 (mg/kg)	Toxicity Category	MRID No. Author/Year	Study Classification
Mallard (<i>Anas platyrhynchos</i>)	97	6.54	very highly toxic	00160000 1984/Hudson	supplemental
Northern bobwhite quail (<i>Colinus virginianus</i>)	technical	12.0	highly toxic	EDODIS00 Hill	core
Northern bobwhite quail (<i>Colinus virginianus</i>)	technical	28	highly toxic	0095655 1977	core
Northern bobwhite quail (<i>Colinus virginianus</i>)	technical	31	highly toxic	0095655 1977	core
Northern bobwhite quail (<i>Colinus virginianus</i>)	98.7	39	highly toxic	42585803 /1992	core
Ring-necked pheasant (<i>Phasianus colchicus</i>)	technical	11.9	highly toxic	00160000 1987/Hudson	core
Red-winged blackbird (<i>Agelaius phoeniceus</i>)	technical	3.2	very highly toxic	1987	supplemental
Northern bobwhite quail (<i>Colinus virginianus</i>)	15G	220	moderately toxic	25525 1969	core
Northern bobwhite quail (<i>Colinus virginianus</i>)	15G	97	moderately toxic	25525 1969	core
Northern bobwhite quail (<i>Colinus virginianus</i>)	15G	14.5	highly toxic	0095655 1984	supplemental
Northern bobwhite quail (<i>Colinus virginianus</i>)	15G	29	highly toxic	EDODIS00 1984	supplemental
Northern bobwhite quail (<i>Colinus virginianus</i>)	sulfone metabolite 87.4	18	highly toxic	42585103 1992	core
Northern bobwhite quail (<i>Colinus virginianus</i>)	sulfoxide metabolite 85.3	9.2	very highly toxic	42585102 1992	core

These results indicate that disulfoton is highly toxic to very highly toxic to avian species on an acute oral basis. The guideline requirement (71-1) is fulfilled (MRID # 42585803). Additionally, the two major metabolites of disulfoton, disulfoton sulfone and disulfoton sulfoxide, are highly toxic and very highly toxic, respectively. Guideline 71-1 is fulfilled for the two major degradates of disulfoton (42585103 and 42585102).

Two subacute dietary studies using the technical grade of the active ingredient are required to establish the toxicity of a pesticide to birds. The preferred test species are mallard duck (a waterfowl) and bobwhite quail (an upland gamebird). Subacute dietary testing on the two major metabolites of disulfoton, disulfoton sulfone and disulfoton sulfoxide, were also required, due to the relative persistence of these degradates. Results of all avian subacute dietary tests are as follows:

Table 12. Avian Subacute Dietary Toxicity					
Species	% ai	LC50 (ppm)	Toxicity Category	MRID No. Author/Year	Study Classification
Northern bobwhite quail (<i>Colinus virginianus</i>)	technical	544	moderately toxic	0094233 Lamb/1973	core
Mallard duck (<i>Anas platyrhynchos</i>)	technical	510	moderately toxic	0034769 Hill/1975	core
Japanese quail (<i>Coturnix japonica</i>)	technical	333	highly toxic	0034769 Hill/1975	supplemental
Mallard duck (<i>Anas platyrhynchos</i>)	sulfone metabolite 87.4	622	moderately toxic	42585101 1992	core
Northern bobwhite quail (<i>Colinus virginianus</i>)	sulfone metabolite 87.4	558	moderately toxic	42585106 1992	core
Mallard duck (<i>Anas platyrhynchos</i>)	sulfoxide metabolite 85.3	823	moderately toxic	42585104 1992	core
Northern bobwhite quail (<i>Colinus virginianus</i>)	sulfoxide metabolite 85.3	456	highly toxic	42585105 1992	core

These results indicate that disulfoton is highly toxic to avian species on a subacute dietary basis. The guideline requirement (71-2) is fulfilled (ACC # 0094233 and 0034769). Additionally, the major metabolites of disulfoton, disulfoton sulfone and disulfoton sulfoxide, are moderately to highly toxic to avian species on a dietary basis. Guideline 71-2 is fulfilled for both metabolites (MRID #42585101, 42585106, 42585104, and 42585105).

ii. Birds, Chronic

Avian reproduction studies using the technical grade of the active ingredient are required for disulfoton because the following conditions are met: (1) birds may be subject to repeated or continuous exposure to the pesticide, especially preceding or during the breeding season, (2) the pesticide is stored or accumulated in plant or animal tissues, and/or, (4) information derived from mammalian reproduction studies indicates reproduction in terrestrial vertebrates may be adversely affected by the anticipated use of the product. Disulfoton meets all of these conditions. The preferred test species are mallard duck and bobwhite quail. Results of these tests are tabulated below.

Table 13. Avian Reproductive Toxicity					
Species	% ai	NOAEC/LOAEC (ppm)	Endpoints Affected	MRID No. Author/Year	Study Classification
Northern bobwhite quail (<i>Colinus virginianus</i>)	98.7	37/74	hatchling body weight	43032501 /1993	core
Mallard duck (<i>Anas platyrhynchos</i>)	98.3	37/80	adult and hatchling body weight	43032502 /1993	core

There was a statistically significant reduction in hatchling body weight at 74 ppm in the bobwhite quail study; however, there were no significant differences in hatchling body weights by day 14 post-hatch. No other effects were observed in this study.

Adult and hatchling body weights were significantly reduced at 80 and 164 ppm in the mallard study, and body weight gain in adults was significantly reduced throughout the study at these two treatment levels as well. Other effects observed at the 164 ppm level were: significantly fewer eggs laid per hen, reduced eggshell strength and thickness, reduced number of hatchlings as a percent of viable embryos, reduced number of 14-day survivors as a percent of normal hatchlings, reduced viable embryos as a percent of eggs set, and reduced 14-day survivors as a percentage of eggs set. The guideline requirement for avian reproduction testing (71-4) is fulfilled (MRID # 43032501, and 43032502).

iii. Mammals, Acute and Chronic

Wild mammal testing is required on a case-by-case basis, depending on the results of lower tier laboratory mammalian studies, intended use pattern and pertinent environmental fate characteristics. In most cases, rat or mouse toxicity values obtained from the Agency's Health Effects Division (HED) substitute for wild mammal testing. These toxicity values are reported in the Table below.

Table 14. Mammalian Acute Toxicity				
Species	% ai	Test Type	Toxicity Values/category	MRID No.
Mule deer (<i>Odocoileus hemionus</i>)	97	acute oral	2.5 mg/kg very highly toxic	00160000
Domestic goat (<i>Capra hircus</i>)	97	acute oral	< 15 mg/kg very highly toxic	00160000
Laboratory rat (<i>Rattus norvegicus</i>)	94.4	acute oral	1.9 mg/kg females I 6.2 mg/kg males I	072293
Laboratory mouse (<i>Mus musculus</i>)	94.4	acute oral	8.2 mg/kg (female) I 7.0 mg/kg (male) I	072293
Laboratory rat (<i>Rattus norvegicus</i>)	sulfone metabolite	acute oral	11.24 mg/kg (female)I	0071873

Test results indicate that disulfoton is very highly toxic (Category I) to small mammals on an acute oral basis. Testing on the sulfone metabolite also indicates very high acute oral toxicity.

Table 15. Mammalian Chronic Toxicity				
Species	% ai	Test Type	Toxicity Values/category	MRID No.
Laboratory rat (<i>Rattus norvegicus</i>)	97.8	2-generation reproduction	maternal NOAEC=2.4 ppm/LOAEC=7.2 ppm repro NOAEC=0.8 ppm/LOAEC=2.4 ppm	261990

The two-generation rat reproduction study provided a reproductive NOEC level of 0.8 ppm. Parameters affected in the study included decreased litter size, lowered pup survival, and decreased pup weight.

iv. Insects

A honey bee acute contact study using the technical grade of the active ingredient is required for disulfoton because its use may result in honey bee exposure. Results of this test are as follows:

Table 16. Nontarget Insect Acute Contact Toxicity					
Species	% ai	LD50 (μ g/bee)	Toxicity Category	MRID No. Author/Year	Study Classification
Honey bee (<i>Apis mellifera</i>)	technical	4.1	moderately toxic	05004151 1968	core
Honey bee (<i>Apis mellifera</i>)	sulfone metabolite 91.6	0.96	highly toxic	42582902 1992	core
Honey bee (<i>Apis mellifera</i>)	sulfoxide metabolite 85.3	1.11	moderately toxic	42582901 1992	core

The results indicate that disulfoton is moderately toxic to bees and disulfoton sulfone, and disulfoton sulfoxide are very highly toxic to bees on an acute contact basis. The guideline requirement (141-1) is fulfilled for parent disulfoton (MRID #05004151), as well as for the two major metabolites (MRID #42582902, 42582901).

A honey bee toxicity of residues on foliage study using the typical end-use product was submitted for disulfoton. The results of this study are tabulated below.

Table 17. Nontarget Insect Toxicity of Residues on Foliage					
Species	Formulation	LD50 (lb. /A)	Toxicity Category	MRID or ACC # Author/year	Guideline Classification
Honey bee (<i>Apis mellifera</i>)	8 E.C.	> 1.0		0163423	core

The results indicate that disulfoton residues on foliage are not toxic to honey bees at application rates up to 1.0 lb /A. Guideline 141-2 is fulfilled for disulfoton (ACC #0163423).

v. Terrestrial Field Testing

Terrestrial field testing was conducted for disulfoton because of the high toxicity of the chemical in relation to expected environmental concentrations. Three field studies were originally required in the 1985 Registration Standard, but only one screening level field study and one residue monitoring study were submitted. The Level I (screening) field study was conducted on potatoes in Benton county, Washington, using the 15G formulation (MRID #410560-01). The study did show mortality to wildlife from the use of the 15G formulation on potatoes; since it was a screening study, there were no further conclusions. If no mortality had been observed, the study would not have been classified as core as the study design and carcass searching techniques were insufficient to negate the presumption of risk. The study fulfilled Guideline 71-

5 only because adverse effects were seen. The fact that bird and mammal carcasses were found even with such an insensitive study design emphasizes the high acute risk this chemical poses to terrestrial vertebrates.

The residue monitoring study (MRID #412018-01) was conducted with Di-Syston 8 (foliar) on potatoes in Michigan. Disulfoton was aerially applied to potatoes 3 times at 1 lb ai/acre in Michigan. The results of this study indicated that there was hazard to terrestrial wildlife from the foliar application of disulfoton, and also suggested that a full Level 1 field study was needed with the foliar application. An second residue monitoring study (MRID #411189-01) was performed, in which disulfoton was soil incorporated by ground equipment, (initially in furrow at planting at 3 lb ai/ acre and 6 - 7 weeks later as a side dressing at 3 lbs ai/ acre). Although the residues on vegetation were much lower in this second study as compared to the first, nevertheless they posed potential acute and chronic risk especially to small mammals.

B. Toxicity to Freshwater Aquatic Animals

i. Freshwater Fish, Acute

Two freshwater fish toxicity studies using the technical grade of the active ingredient are required to establish the toxicity of a pesticide to fish. The preferred test species are rainbow trout (a Coldwater fish) and bluegill sunfish (a warmwater fish). Results of these tests are as follows:

Table 18. Freshwater Fish Acute Toxicity					
Species	% ai	LC50 (ppb ai)	Toxicity Category	MRID No. Author/Year	Study Classification
Rainbow trout (<i>Oncorhynchus mykiss</i>)	98	1,850	moderately toxic	40098001 F.L. Mayer/1986	core
	tech	3,000	moderately toxic	0068268 Lamb/1972	core
	15G	13,900	slightly toxic	0068268 Lamb/1972	core
	65EC	3,500	moderately toxic	0068268 Lamb/1972	core
	sulfone metabolite sulfoxide metabolite	>9,200	moderately toxic	42585111 Gagliano/1992	core
		60,300	slightly toxic	42585110 Gagliano/1992	core
Bluegill sunfish (<i>Lepomis macrochirus</i>)	98.0	300	highly toxic	40098001 F.L. Mayer/1986	core
	Tech	39	very highly toxic	0068268 Lamb/1972	core
	15G	250	highly toxic	0068268 Lamb/1972	core
	65EC	59	very highly toxic	0068268 Lamb/1972	core
	20E	8.2	very highly toxic	229299 1962	supplemental
	sulfone metabolite sulfoxide metabolite	112	highly toxic	42585108 Gagliano/1992	core
		188	highly toxic	42585107 Gagliano/1992	core
Channel catfish (<i>Ictalurus punctatus</i>)	98.0	4,700	moderately toxic	40098001 Mayer/1986	core
Goldfish (<i>Carassius auratus</i>)	90	7,200	moderately toxic	229299 1962	supplemental
Largemouth bass (<i>Micropterus salmoides</i>)	98.0	60	very highly toxic	40098001 Mayer/1986	core
Fathead minnow (<i>Pimphales promelas</i>)	98.0	4,300	moderately toxic	40098001 Mayer/1986	core
Guppy	90	280	highly toxic	229299	supplemental

These results indicate that parent disulfoton is very highly toxic to slightly toxic to freshwater fish on an acute basis. The two major metabolites, disulfoton sulfone and disulfoton sulfoxide, are highly toxic to slightly toxic to freshwater fish on an acute basis. The rainbow trout, a Coldwater species, appears to be somewhat less sensitive than the warmwater species to disulfoton and its metabolites. The guideline requirement (72-1) is fulfilled for parent disulfoton, disulfoton sulfone, and disulfoton sulfoxide.

ii. Freshwater Fish, Chronic

A freshwater fish early life-stage test using the technical grade of the active ingredient is required for a pesticide when it may be applied directly to water or if the end-use product is expected to be transported to water from the intended use site, and the following conditions are met: (1) the pesticide is intended for use such that its presence in water is likely to be continuous or recurrent regardless of toxicity, (2) any aquatic acute LC50 or EC50 is less than 1 mg/l, (3) the EEC in water is equal to or greater than 0.01 of any acute LC50 or EC50 value, or, (4) the actual or estimated environmental concentration in water resulting from use is less than 0.01 of any acute LC50 or EC50 value and any one of the following conditions exist: studies of other organisms indicate the reproductive physiology of fish may be affected, physicochemical properties indicate cumulative effects, or the pesticide is persistent in water (e.g., half-life greater than 4 days). The preferred test species is rainbow trout, but other species may be used.. Freshwater fish early life-stage testing was required for disulfoton due to the likelihood of drift and runoff from the application sites, the likelihood of repeated or continuous exposure from multiple applications, and the high acute toxicity to several species of freshwater fish. Results of this test are tabulated below.

Table 19. Freshwater Fish Early Life-Stage Toxicity						
Species	% ai	NOAEC/LOAEC (ppb ai)	MATC (ppb)	Endpoints Affected	MRID No. Author/Year	Study Classification
Rainbow trout (<i>Oncorhynchus mykiss</i>)	98	220/420	300	growth	41935801 1991	core

The guideline requirement (72-4a) is fulfilled (MRID 41935801).

A freshwater fish life-cycle test using the technical grade of the active ingredient is not required for disulfoton. A marine/estuarine fish life-cycle test was conducted with disulfoton, since the marine/estuarine species is more sensitive than the freshwater species. This is discussed in section c ii , below.

iii. Freshwater Invertebrates, Acute

A freshwater aquatic invertebrate toxicity test using the technical grade of the active ingredient

is required to establish the toxicity of a pesticide to invertebrates. The preferred test species is *Daphnia magna*. Results of this test are tabulated below.

Table 20. Freshwater Invertebrate Toxicity					
Species	% ai	LC50/ EC50 (ppb ai)	Toxicity Category	MRID No. Author/Year	Study Classification
Waterflea (<i>Daphnia magna</i>)	98.6	13.0	very highly toxic	00143401 Heimbach/1985	core
Waterflea (<i>Daphnia magna</i>)	Sulfone metabolite 87.4	35.2	very highly toxic	42585112 Gagliano/1992	core
Waterflea (<i>Daphnia magna</i>)	sulfoxide metabolite 85.3	64	very highly toxic	42585109 Gagliano/1992	core
Scud (<i>Gammarus fasciatus</i>)	98	52	very highly toxic	40098001 Mayer/1986	supplemental
	technical	27	very highly toxic	05017538 1972	supplemental
Glass shrimp (<i>Palaemonetes kadiakensis</i>)	98	3.9	very highly toxic	40094602 1980	supplemental
Stonefly (<i>Acroeuria pacifica</i>)	89	<8.2	very highly toxic	229299 1962	supplemental
Stonefly (<i>Pteronarcys californica</i>)	98	5.0	very highly toxic	40098001 Mayer/1986	core

The results indicate that disulfoton and its metabolites, disulfoton sulfone and disulfoton sulfoxide, are very highly toxic to aquatic invertebrates on an acute basis. The guideline requirement (72-2) is fulfilled.

iv. Freshwater Invertebrate, Chronic

A freshwater aquatic invertebrate life-cycle test using the technical grade of the active ingredient is required for a pesticide if the end-use product may be applied directly to water or expected to be transported to water from the intended use site, and the following conditions are met: (1) the pesticide is intended for use such that its presence in water is likely to be continuous or recurrent regardless of toxicity, (2) any aquatic acute LC50 or EC50 is less than 1 mg/l, or, (3) the EEC in water is equal to or greater than 0.01 of any acute EC50 or LC50 value, or, (4) the actual or estimated environmental concentration in water resulting from use is less than 0.01 of any aquatic acute EC50 or LC50 value and any of the following conditions exist: studies of other

organisms indicate the reproductive physiology of invertebrates may be affected, physicochemical properties indicate cumulative effects, or the pesticide is persistent in water (e.g., half-life greater than 4 days). The preferred test species is *Daphnia magna*. Freshwater aquatic invertebrate life-cycle testing was required for disulfoton. Results of this test are tabulated below.

Table 21. Freshwater Aquatic Invertebrate Life-Cycle Toxicity						
Species	% ai	NOAEC/LOAE C (ppb)	MATC (ppb)	Endpoints Affected	MRID No. Author/Year	Study Classifica tion
Waterflea (<i>Daphnia magna</i>)	98	0.037/0.070	0.051	survival, length, and # young/adult	41935802 Blakemore/1991	core
Waterflea (<i>Daphnia magna</i>)	99.3 Sulfone	0.14/0.27	0.19	length	43738001 Bowers/1995	core
Waterflea (<i>Daphnia magna</i>)	98.9 Sulfoxide	1.53/2.97	2.13	Weight & length	43738002 Bowers/1995	core

The guideline requirement (72-4) is fulfilled (MRID #41935802).

v. Freshwater Field Studies

A microcosm study was conducted to evaluate the effects of runoff of disulfoton on a simulated aquatic field system (MRID #435685-01/Cook and Kennedy, 1994). Three dose levels -- 3, 10, 30 ppb --were established in two replicate tanks per dose. Each tank was dosed 4 times at 7 day intervals. The study demonstrated that 3 ppb is the maximum acceptable toxicant concentration (MATC) for this chemical in aquatic systems. At treatment levels of 3 ppb and higher, adverse effects were seen on zooplankton numbers, zooplankton community similarity, adult macro invertebrate population numbers, and adult macroinvertebrate community composition; however, some recovery trend was observed on all of these parameters at 10 ppb and many at 30 ppb by the end of the 77 day study. A bluegill LC50 of 25 ppb and LC10 of 4.7 ppb was established for the first 27 days during which the four applications occurred.

The North Carolina Cooperative Extension Service submitted two stream surveys conducted in five of the major Christmas tree farming in North Carolina. Although neither survey was targeted for disulfoton, nor analyzed for chemical residues they attempted to reflect the impact to aquatic macro invertebrates from the overall cultural practices associated with Christmas tree farming in Western North Carolina. The first survey, conducted by Department of Environmental Health and Natural Resources (DEHNR), examined one station on each of 11 streams (Lenant, D. 1999 unpublished). Eight of the 11 streams were sampled once (in May

presumably after the April/May application of disulfoton). The 3 other streams were sampled a second time in August as a means to correct for likely seasonal changes in the species composition of Ephemeroptera, Plecoptera and Trichoptera (EPT). The second survey was conducted from 12/98 thru early to late summer 1999 (Sidebottom, J. 2000 unpublished). The survey examined 5 sites – each consisting of an area adjacent to or downstream from a Christmas tree farm paired with its own reference site (either a station on the same stream, but above the tree farm or a second stream). The data collected included the total number of insects and the break out (expressed as a % of insects) for mayflies, stoneflies, caddisflies, riffle beetles and “other” insects. A species list for mayflies, stoneflies and caddisflies along with an index of their sensitivity and the dates collected was provided for 3 of the 5 sites. See the risk to aquatic organisms section on page 64 for further discussion of results and the significance to the disulfoton risk assessment.

C. Toxicity to Estuarine and Marine Animals

i. Estuarine and Marine Fish, Acute

Acute toxicity testing with estuarine/marine fish using the technical grade of the active ingredient is required for a chemical when the end-use product is intended for direct application to the marine/estuarine environment or the active ingredient is expected to reach this environment because of its use in coastal counties. The preferred test species is sheepshead minnow. Marine/estuarine acute testing was conducted with disulfoton. Results of these tests are tabulated below.

Table 22. Acute Toxicity of Disulfoton to Estuarine/Marine Fish					
Species	% ai	LC50 (ppb)	Toxicity Category	MRID No. Author/Year	Study Classification
Sheepshead minnow (<i>Cyprinodon variegatus</i>)	95.5	520	highly toxic	4022840 Mayer/1986	supplemental
Sheepshead minnow (<i>Cyprinodon variegatus</i>)	97.8	1000	highly toxic	40071602 Surprenant/1986	core
Sheepshead minnow (<i>Cyprinodon variegatus</i>)	Sulfone metabolite 100%	1060	moderately toxic	44369901 Lam/1997	core
Sheepshead minnow (<i>Cyprinodon variegatus</i>)	Sulfoxide metabolite 98.2%	11300	slightly toxic	44369902 Lam/1997	core

The results indicate that disulfoton is highly toxic to estuarine/marine fish on an acute basis. The guideline requirement (72-3a) is fulfilled for parent disulfoton (MRID #40071602) and the sulfone and sulfoxide metabolites (MRID #44369901 and 44369902, respectively).

ii. Estuarine and Marine Fish, Chronic

Estuarine/marine fish early life-stage and life-cycle tests using the technical grade of the active ingredient were required for disulfoton due to the high acute toxicity to estuarine/marine fish. The results of these studies are as follows:

Table 23. Chronic Toxicity of Disulfoton to Marine/Estuarine Fish

Species	% a.i.	Test Type	NOEC/LOEC (ppb)	MAT C (ppb)	Parameters Affected	MRID # Author/year	Classification
Sheepshead minnow (<i>Cyprinodon variegatus</i>)	97.4	early life-stage	16.2/32.9	23.1	survival, length, wet weight	42629001 Lintott/1993	core
Sheepshead minnow (<i>Cyprinodon variegatus</i>)	98	life-cycle	0.96 ¹ /2.9	1.7	fecundity, morphological abnormalities, growth, hatching success	43960501 Dionne/1996	supplemental

¹An actual NOEC was not achieved in this study. The value reported here is an EC05, extrapolated using linear regression.

The results indicate that disulfoton impacts the reproductive ability, as well as the growth and larval survival, of sheepshead minnows at levels as low as 2.9 ppb. The guideline requirements (72-4 and 72-5) are fulfilled (MRID # 42629001 and 43960501, respectively).

iii. Estuarine and Marine Invertebrates, Acute

Acute toxicity testing with estuarine/marine invertebrates using the technical grade of the active ingredient is required for a pesticide when the end-use product is intended for direct application to the marine/estuarine environment or the active ingredient is expected to reach this environment because of its use in coastal counties. The preferred test species are mysid shrimp and eastern oyster. Estuarine/marine invertebrate testing was required for disulfoton. Results of these tests are as follows:

Table 24. Acute Toxicity of Disulfoton to Estuarine/Marine Invertebrates

Species	% ai.	LC50/EC50 (ppb)	Toxicity Category	MRID No. Author/Year	Study Classification
Eastern oyster (<i>Crassostrea virginica</i>)	97.8	720	highly toxic	40071603 Surprenant/1986	core
Eastern oyster (<i>Crassostrea virginica</i>)	tech	900	highly toxic	120480 /1965	supplemental
Eastern oyster (<i>Crassostrea virginica</i>)	95.5	720	highly toxic	40228401 Mayer/1986	core
Mysid (<i>Mysidopsis bahia</i>)	97.8	100	very highly toxic	40071601 Surprenant/1986	core
Brown shrimp (<i>Penaeus aztecus</i>)	95.5	15	very highly toxic	40228401 Mayer/1986	supplemental

The results indicate that disulfoton is very highly to highly toxic to estuarine/marine invertebrates on an acute basis. The guideline requirements (72-3b and 72-3c) are fulfilled (MRID #40071603 and 40071601, respectively).

iv. Estuarine and Marine Invertebrate, Chronic

An estuarine/marine invertebrate life-cycle toxicity test is required for a pesticide if the end-use product may be applied directly to water or expected to be transported to water from the intended use site, and the following conditions are met: (1) the pesticide is intended for use such that its presence in water is likely to be continuous or recurrent regardless of toxicity, (2) any aquatic acute LC50 or EC50 is less than 1 mg/l, or, (3) the EEC in water is equal to or greater than 0.01 of any acute EC50 or LC50 value, or, (4) the actual or estimated environmental concentration in water resulting from use is less than 0.01 of any aquatic acute EC50 or LC50 value and any of the following conditions exist: studies of other organisms indicate the reproductive physiology of invertebrates may be affected, physicochemical properties indicate cumulative effects, or the pesticide is persistent in water (e.g., half-life greater than 4 days). Estuarine/marine invertebrate testing was required for disulfoton due to its high acute toxicity to estuarine/marine organisms, and the greater acute sensitivity of marine/estuarine organisms compared to freshwater organisms. The results of this test are as follows:

Table 25. Life-Cycle Toxicity of Disulfoton to Estuarine/Marine Invertebrates						
Species	% ai	NOEC/LOEC C (ppb)	MATC (ppb)	Parameters Affected	MRID # Author/Year	Classification
Mysid (<i>Mysidopsis bahia</i>)	98.5	2.35 ¹ /8.26	5.30	growth	43610901 Davis/1995	core

¹A NOEC was not achieved in the study, so an extrapolated EC₀₅ for growth was calculated using linear regression. The MATC reported is the mean between the EC₀₅ and LOEC values.

The growth of mysids was adversely affected at levels of 8.26 ppb and higher. Production and survival of young was adversely affected at levels of 120 ppb and higher.

v. Estuarine and Marine Field Studies

No estuarine or marine field study data is available for disulfoton.

D. Toxicity to Plants

i. Terrestrial

Currently, terrestrial plant testing is not required for pesticides other than herbicides except on a case-by-case basis (e.g., labeling bears phytotoxicity warnings, incidents of plant damage have been reported, or literature indicating phytotoxicity is available). The insecticide disulfoton does have phytotoxicity warnings on product labels; therefore, Tier I terrestrial plant testing (Guideline 122-1) is required for disulfoton. No such data have been submitted to date.

ii. Aquatic Plants

Aquatic plant testing is not required for pesticides other than herbicides except on a case-by-case basis (e.g., labeling bears phytotoxicity warnings, incidents have been reported involving plants, or literature is available that indicates phytotoxicity). The insecticide disulfoton does have phytotoxicity warnings on product labels; therefore, Tier I aquatic plant testing (Guideline 122-2) is required for disulfoton. No such data have been submitted to date.

4. Ecological Risk Assessment

Risk assessment integrates the results of the exposure and ecotoxicity data to evaluate the likelihood of adverse ecological effects. One method of integrating the results of exposure and ecotoxicity data is called the quotient method. For this method, risk quotients (RQs) are calculated by dividing exposure estimates by ecotoxicity values, both acute and chronic.

$$RQ = \text{EXPOSURE/TOXICITY}$$

RQs are then compared to OPP's levels of concern (LOCs). These LOCs are criteria used by OPP to indicate potential risk to nontarget organisms and the need to consider regulatory action. The criteria indicate that a pesticide used as directed has the potential to cause adverse effects on nontarget organisms. LOCs currently address the following risk presumption categories: (1) **acute** - potential for acute risk is high regulatory action may be warranted in addition to restricted use classification (2) **acute restricted use** - the potential for acute risk is high, but this may be mitigated through restricted use classification (3) **acute endangered species** - the potential for acute risk to endangered species is high regulatory action may be warranted, and (4) **chronic risk** - the potential for chronic risk is high regulatory action may be warranted. Currently, EFED does not perform assessments for chronic risk to plants, acute or chronic risks to nontarget insects, or chronic risk from granular/bait formulations to mammalian or avian species.

The ecotoxicity test values (i.e., measurement endpoints) used in the acute and chronic risk quotients are derived from the results of required studies. Examples of ecotoxicity values derived from the results of short-term laboratory studies that assess acute effects are: (1) LC50 (fish and birds) (2) LD50 (birds and mammals) (3) EC50 (aquatic plants and aquatic invertebrates) and (4) EC25 (terrestrial plants). Examples of toxicity test effect levels derived from the results of long-term laboratory studies that assess chronic effects are: (1) LOEC (birds, fish, and aquatic invertebrates) (2) NOEC (birds, fish and aquatic invertebrates) and (3) MATC (fish and aquatic invertebrates). For birds and mammals, the NOEC value is used as the ecotoxicity test value in assessing chronic effects. Other values may be used when justified. Generally, the MATC (defined as the geometric mean of the NOEC and LOEC) is used as the ecotoxicity test value in assessing chronic effects to fish and aquatic invertebrates. However, the NOEC is used if the measurement end point is production of offspring or survival.

Risk presumptions, along with the corresponding RQs and LOCs are tabulated below.

Table 26. Risk Presumptions for Terrestrial Animals

Risk Presumption	RQ	LOC
Birds and Wild Mammals		
Acute Risk*	EEC ¹ /LC50 or LD50/sqft ² or LD50/day ³	0.5
Acute Restricted Use	EEC/LC50 or LD50/sqft or LD50/day (or LD50 < 50 mg/kg)	0.2
Acute Endangered Species	EEC/LC50 or LD50/sqft or LD50/day	0.1
Chronic Risk	EEC/NOAEC	1

¹ abbreviation for Estimated Environmental Concentration (ppm) on avian/mammalian food items

² $\frac{\text{mg}}{\text{ft}^2}$ ³ $\frac{\text{mg of toxicant consumed}}{\text{day}}$

LD50 * wt. of bird LD50 * wt. of bird

* In the past, this category read 'Acute High Risk.' The EFED is changing the wording of the conclusions to "Acute Risk" when the acute LOC exceedences are based solely on a screening level assessment.

Table 27. Risk Presumptions for Aquatic Animals

Risk Presumption	RQ	LOC
Acute Risk*	EEC ¹ /LC50 or EC50	0.5
Acute Restricted Use	EEC/LC50 or EC50	0.1
Acute Endangered Species	EEC/LC50 or EC50	0.05
Chronic Risk	EEC/MATC or NOAEC	1

¹ EEC = (ppm or ppb) in water

* In the past, this category read 'Acute High Risk.' The EFED is changing the wording of the conclusions to "Acute Risk" when the acute LOC exceedences are based solely on a screening level assessment.

Table 28. Risk Presumptions for Plants

Risk Presumption	RQ	LOC
Terrestrial and Semi-Aquatic Plants		
Acute Risk*	EEC ¹ /EC25	1
Acute Endangered Species	EEC/EC05 or NOEC	1
Aquatic Plants		
Acute Risk*	EEC ² /EC50	1
Acute Endangered Species	EEC/EC05 or NOAEC	1

¹ EEC = lbs ai/A

² EEC = (ppb/ppm) in water

* In the past, this category read 'Acute High Risk.' The EFED is changing the wording of the conclusions to "Acute Risk" when the acute LOC exceedences are based solely on a screening level assessment.

A. Risk to Nontarget Terrestrial Animals

i. Acute and Chronic Risk to Birds and Mammals from Nongranular products.

Nongranular formulations of disulfoton are applied either as a foliar spray (often by air), or as a spray directly to soil either preplant, or to soil beside the crop (potato side dressing). Foliar sprays are assumed to settle directly onto vegetation and other avian and mammalian food items. The residues on these food items are estimated by using a nomograph reported Hoerger and Kenega, 1972, and as modified by Fletcher, et al, 1994.

The acute risk quotients for broadcast applications of nongranular products are presented below.

Table 29. Avian and Mammal Acute Risk Quotients for peak exposure levels based on maximum residue values. Assuming an avian dietary LC50 of 333 ppm (Japanese quail), and mammal LD50 of 1.9 mg/kg and a 3.3-day half-life

The mammalian LD50 of 1.9 mg/kg was used to estimate 1-day LC50s for three different sized mammals:

15 gram mammal that eats 0.95 of its body weight per day: LC50 = 2 ppm

35 gram mammal that eats 0.66 of its body weight per day: LC50 = 2.9 ppm

1000 gram mammal that eats 0.15 of its body weight per day: LC50 = 12.7 ppm

Formula: 1-day LC50 = LD50 (mg/kg) / proportion of body weight consumed

Use Scenarios		Maximum Exposure (EEC in ppm) ¹ and RQ EEC/LC50							
		BIRDS				MAMMALS			
		short grass	broad leaf	long grass	seeds fruit	short grass	broad leaf	long grass	seeds fruit
Tobacco ; soil (ground); 4 lbs ai/acre; 1 appl per season	EEC	960	540	440	60	960	540	440	60
	RQ	2.8	1.6	1.3	0.2	15 g 35 g 1000 g	480 331 75	270 186 42	220 151 34 30 20 4
Beans; soil ; 2 lbs ai/acre; 1 appl per season	EEC	480	270	220	30	480	270	220	30
	RQ	1.4	0.8	0.7	0.1	15 g 35 g 1000 g	240 186 42	135 93 21	110 75 17 15 10 2
Broccoli and wheat; soil; 1 lbs ai/acre; 1 appl per season.	EEC	240	135	110	15	240	135	110	15
	RQ	0.7	0.4	0.3	<0.1	15 g 35 g 1000 g	120 82 18	67 46 10	55 37 8 7 5 1
Potato; soil (ground); 4 lbs ai/acre; 2 appl per season; 14 day interval	EEC	1010	568	463	63	1010	568	463	63
	RQ	3.0	1.7	1.4	0.2	15 g 35 g 1000 g	505 348 79	284 195 44	231 159 36 31 21 4
Pecans & potatoes; (aerial/ ground); 1 lb ai/acre; 3 appl per season; 14-day interval	EEC	253	142	116	15	253	142	116	15
	RQ	0.7	0.4	0.3	<0.1	15 g 35 g 1000 g	126 87 19	71 48 11	58 40 9 7 5 1
Sorghum; soil (aerial/ ground); 1 lb ai/acre; 2 appl per season; 14-day interval	EEC	252	142	115	15	252	142	115	15
	RQ	0.7	0.4	0.3	<0.1	15 g 35 g 1000 g	126 87 19	71 48 11	57 40 9 7 5 1
Sorghum; foliar (aerial/ ground); 0.5 lb ai/acre; 3 appl per season; 14-day interval	EEC	126	71	58	7	126	71	58	7
	RQ	0.4	0.2	0.2	<0.1	15 g 35 g 1000 g	63 43 9	35 24 5	29 20 4 3 2 0.5

¹The maximum exposure level is the highest level estimated based on the Hoerger and Kenega nomograph as modified by Fletcher, 1994. For scenarios with single applications, the maximum level is the concentration immediately after the treatment. For scenarios with multiple applications, the maximum concentration is that which occurs immediately after the final application.

Bolded RQs meet or exceed the acute risk LOC (0.5) as well as the restricted use and endangered species LOCs.;

<0.1 indicates no LOCs are exceeded;

0.1 or higher suggest effects to endangered or threatened species;

0.2 or higher indicates use pattern should be considered for restricted use

The results of the risk screen indicate acute LOCs for risk, restricted use and endangered species are exceeded for birds at application rates above 1 lb ai / acre, and for mammals at all application rates.

Although soil applications are intended to be applied to bare soil, the risk quotients do include residues on grass and broad leaf plant material. Not only does this represent risk that might occur from contaminated vegetation inadvertently left in the fields at the time of treatment, but also compensates for not being able to address such additional routes of exposure as dermal, inhalation or drinking contaminated water. Within fields at the time of planting, vegetation is expected to be sparse, thereby reducing exposure and risk; however, the vegetation on the field margins will receive drift from both ground and aerial applications. Furthermore, many of disulfoton's soil applied, soil incorporated ground applications are side dressings to emergent crops such as potatoes and cotton. In those instances, residues do appear on the under story of the crop and any weeds that are not incorporated (especially those at the field edge). The primary food items remaining in tilled fields are seeds and invertebrates. Insect residue were not estimated using the nomograph, however, for screening purposes, residues on insects may be similar to seeds and broad leafs, depending on the size of the insects.

Another source of uncertainty in the acute risk assessment for mammals is the credibility of the 1 day LC50 values derived from the rat LD50 of 1.9 mg/kg when comparing the range of the 1 day LC50s (2-12.7 ppm) to the rat LC50 (320 ppm 95% CI[0 - infinity]) for demeton. Demeton is an active ingredient that consists of a mixture of two isomers -- demeton -S and demeton-O in a ratio of 65:35. Demeton-O is structurally identical to the oxygen analog of disulfoton. The following tables illustrate the toxicological similarity between demeton and disulfoton.

Table 30. Toxicity of Demeton to Birds and mammals

Species	LC50 (ppm)	95% CI	Source
Mallard	598	488-733	Hill 1975
Bobwhite quail	596	472-768	Hill 1975
Japanese quail	275	218-345	Hill 1986
Ring-necked Pheasant	665	572-773	Hill 1975
Rat	319	0-infinity	McCaan 1981
	LD50 (mg/kg)		
Rat -male	6.2		Gaines 1969
Rat-female	2.5		Gaines 1969
Red-wing Blackbird	2.37-22.0 ^a		Schafer 1983

Table 31. Toxicity of Disulfoton to Birds and mammals

Species	LC50 (ppm)	95% CI	Source
Mallard	510	415-625	Hill 1975
Bobwhite quail	715	617-827	Hill 1975
Japanese quail	334	275-405	Hill 1986
Ring-necked Pheasant	634	547-737	Hill 1975
	LD50 (mg/kg)	95% CI	
Rat -male	6.82	5.9-7.8	Gaines 1969
Rat-female	2.3	1.7-3.1	Gaines 1969
Red-wing Blackbird	3.2	1.8-5.6	Schafer 1983

^a a Range of LD50 values obtained in multiple studies

The above data suggests a very similar toxicity profile for demeton and disulfoton. Therefore, one might consider disulfoton's rat dietary LC50 to be approximately 320 ppm. Unfortunately, there is uncertainty for this assumption due to the extremely wide 95% CI for demeton's rat dietary LC50 study--zero to infinity. Even when allowing for the possibility the LC50 is 320 ppm would mean foliar applications of 1.0 lb ai/A applied more than once would exceed the acute risk LOC--especially for herbivores. However, higher rates of soil directed sprays applied by ground equipment would not exceed the acute risk for herbivores.

The following table presents a screening level chronic risk assessment for both birds and mammals. The toxicity values used in the table are the NOAEL from the avian reproduction study (37 ppm) and the mammal 2-generation rat reproduction study (0.8 ppm). Both peak EECs and time weighted averages of EECs based on Fletcher maximum residues are used to calculate risk quotients. The peak EEC is shown only for short grass, since that would represent the highest level. The time weighted averages of maximum EECs are calculated by dissipating maximum residues over 30-days and averaging the daily residues.

Table 32. Avian and Mammal Chronic Risk Quotients based on peak (for short grass) and maximum 30 day average levels. Assuming an avian NOAEL of 37 ppm (Bobwhite), a mammal NOAEL of 0.8 ppm and a 3.3-day halflife

Nongranular Use Scenarios		30-day Maximum Average EEC in ppm ¹ and RQs			
		AVIAN and MAMMALS			
		CHRONIC RQs (EEC / NOAEL)			
		short grass (peak residue)	broad leaf	long grass	seeds/ fruit
Tobacco ; soil (ground); 4 lbs ai/acre; 1 appl per season	EEC	168 (960)	94	77	10
	AVIAN RQ	4.5 (25)	2.5	2	0.2
	MAMMAL RQ	210 (1200)	117	96	12
Beans; soil ; 2 lbs ai/acre; 1 appl per season	EEC	84 (480)	47	38	5
	AVIAN RQ	2.2 (13)	1.2	1	0.1
	MAMMAL RQ	105 (600)	58	47	6
Broccoli and wheat; soil; 1 lbs ai/acre; 1 appl per season.	EEC	42 (240)	23	19	2.6
	AVIAN RQ	1 (6)	0.6	0.1	<0.1
	MAMMAL RQ	52 (300)	28	23	3
Potato; soil (ground); 4 lbs ai/acre; 2 appl per season; 14 day interval	EEC	331(1010)	186	152	20
	AVIAN RQ	8.9 (27)	5	4	0.5
	MAMMAL RQ	413 (1262)	232	190	25
Pecans & potatoes; (aerial/ ground); 1 lb ai/acre; 3 appl per season; 14-day interval (Cotton; soil (ground); 1 lb ai/acre; 3 appl per season; 21-day interval:: should have slightly lower risk due to less off site distribution of spray and peak & average residues are lower)	EEC	88 (253)	49	40	5
	AVIAN RQ	2.4 (6.8)	1.3	1	0.1
	MAMMAL RQ	110 (316)	61	50	6
Sorghum; soil (aerial/ ground);1 lb ai/acre; 2 appl per season; 14-day interval (Barley; foliar (aerial/ ground); 1.0 lb ai/acre; 2 appl per season; 21-day interval: should have slightly lower risk off site, since peak and average residues are lower; however, on site the risk may be higher due to crop foliage being sprayed directly) (Spring wheat; foliar (aerial/ ground); 0.75 lb ai/acre; 2 appl per season; 30-day interval: should have slightly lower risk off site, since peak and average residues are lower; however, on site the risk may be slightly higher due to crop foliage being sprayed directly)	EEC	82 (252)	46	38	5
	AVIAN RQ	2 (6.8)	1.2	1	0.1
	MAMMAL RQ	102 (315)	57	47	6

Table 32. Avian and Mammal Chronic Risk Quotients based on peak (for short grass) and maximum 30 day average levels. Assuming an avian NOAEL of 37 ppm (Bobwhite), a mammal NOAEL of 0.8 ppm and a 3.3-day halflife

Nongranular Use Scenarios		30-day Maximum Average EEC in ppm ¹ and RQs			
		AVIAN and MAMMALS			
		CHRONIC RQs (EEC / NOAEL)			
Sorghum; foliar (aerial/ ground); 0.5 lb ai/acre; 3 appl per season; 14-day interval	EEC	44 (126)	24.9	20	2.7
(Cotton; foliar (aerial/ ground); 0.5 lb ai/acre; 3 appl per season; 21-day interval: should have slightly lower risk since peak and average residues are lower)	AVIAN RQ MAMMAL RQ	1.2 (3.4) 55 (157)	0.6 31	0.5 25	<0.1 3
¹ The exposure level is based on the maximum level for each vegetation category in the Hoerger and Kenega nomograph as modified by Fletcher, 1994. The 30-day average is the average of each daily residue value on the food item dissipated using a 3.3 day halflife. For uses with multiple applications, each subsequent application deposits (adds) another maximum residue to the residue remaining from the previous application(s) and that maximum residue is dissipated over time, a total of 30 days. Bolded RQs meet or exceed the chronic risk LOC (1)					

The above two risk assessment tables were derived from exposure estimates based on maximum Fletcher residue values. The risk screen did not differentiate between foliar treatments and soil applications. It is recognized that applications to bare soil, while not precluding residues on vegetation in and around the field, probably reduce the opportunity and extent of exposure. This would be significant to both the acute risk and chronic risk. The following discussion reports the results of two field residue monitoring studies (MRID 411169-01 and 41201801) reflecting the difference in exposure for liquid formulations of disulfoton associated with foliar and soil applications.

Exposure from aerial applications to foliage

Disulfoton as liquid Di-syston 8E was aerially applied to potatoes 3 times at 1 lb ai/acre in Michigan (MRID 41201801). Potato foliage was collected from five treated fields; 6 sample stations in each field. Samples were collected the day before and the day after each of the three treatments, and then on day 7 and 14 after the third (final) treatment. Residues on noncrop vegetation adjacent to, and invertebrates in, treated fields were also measured. Samples were collected the day after each of three aerial applications of 1 lb ai/acre and 7 days after the third (last) application. The following table shows the peak, mean and upper bound of the 95 % confidence interval residue values of all fields after each treatment.

Table 33. The highest mean, 95 % confidence interval (CI) and peak residues reported during the residue monitoring of terrestrial compartments following 3 aerial applications of Di- syston 8E at 1.0 lbs ai/A to potato fields.

Use Rate	Applic. Number	potato foliage (mean residues ppm)	off-site non-target vegetation (mean residues ppm)	invertebrates in or near treatment site (mean residues ppm)
1 lb ai/acre (at 6-10 day intervals)	1	9-59 (95% CI)	7.1	1.6
	2	18-78 (95% CI)	25	2.7
	3	20-60 (95% CI)	9.3	4.5
	for all treatments	upper 95% CI= 78 mean= 41 peak= 105	upper 95% CI= 71 mean = 14 peak = 152	upper 95% CI=11 mean = 3 peak = 16

As will be discussed these results appear to clearly support Fletcher mean values for broad leaves. The potato foliage was sprayed directly and the mean of 41 ppm for all treatments was only slightly less than Fletcher's mean for broad leaves (45 ppm for a single application and 47 for 3 applications). Though the lower bound 95% CI for application # 1 was 9 ppm (well below a single application mean of 45 ppm), the upper bound 95% CI of 78 ppm for application # 2 was 1.7 times higher than Fletcher's mean of 47 ppm for 3 applications.. The peak on the targeted potato leaves (105 ppm) was less than Fletcher's maximum for broadleaves (135 ppm for a single application and 142 ppm for 3 applications). Nevertheless the peak residue (152 ppm in application # 2) for vegetation in the adjacent areas was greater than Fletcher's maximum for both a single and for 3 applications. Wind direction at the time of application may account for the seeming contradicting location of the peak values. Approximately 50% of the time the wind was moving away from the direction of the within field sampling station and approximately 40% of the time the wind direction was away from the sample station just outside the field perimeter. These monitoring results, coupled with those for azinphos methyl applied to apple orchards (MRID 411397-01 & 411959-01), support EFED's assumption that foliar residues resulting from both single and multiple applications to foliage are estimated reasonably well using Fletcher values in a dissipation model.

Concerning the residues on invertebrates (peak of 16 ppm and an upper bound mean 95% CI of 11 ppm), it is acknowledged that an assumed direct application did not produce residues equal to those on broadleaves (theoretically reflective of small insects), but did compare favorably with Fletcher's estimates for large insects (maximum of 16 ppm and a mean of 7 ppm for 3 applications). The question arises as to whether the sample pool consisted of "small" or "large"

invertebrates. Furthermore, some of the individuals comprising the sample may have been on the underside of a leaf at the time of application and only acquired residues from contacting contaminated soil or leaves. Whereas those individuals (especially the potato beetle) sprayed directly had died. These individuals contained higher residues, but were not part of the pool.

Exposure from ground applications sprayed to soil

A residue monitoring study was conducted in potato fields in Michigan (MRID 411189-01). Disulfoton was applied at 3 lb ai/A as an in-furrow spray application and again as a side dressing after 6-7 weeks. Invertebrates, crop and other vegetation, and soil were sampled within 24 hours after both applications. Invertebrates were collected in grids of pitfall traps in five fields, and potato beetles were collected on foliage by sampling stations. Soil samples were collected from the soil surface to a depth of 2-3 cm. Vegetation was available for sampling only after the second application. Mean and maximum residue values are found in the following table. The limit of detection was 0.09 ppm.

Table 34. Highest mean and (maximum) residues reported during the residue monitoring of terrestrial compartments following 2 soil applications by ground equipment of Disyston 8E at 3.0 lbs ai/A

Application	Invertebrates (ppm)	Soil (ppm)	Edge of field vegetation (ppm)	Potato Foliage (ppm)
1 (in furrow)	0.3 (0.9)	0.19 (1.8)	0.2 (0.9)	4.0 (26)*
2 (side dressing)	0.4 (upper 95% CI=0.6) 1.8	2.9 (upper 95% CI=14) 22	3.5 (upper 95% CI=11) 54	8.0 (upper 95% CI=16) 44

* Just prior to 2nd application

In contrast to foliar applications, ground applications to soil result in residues far below those predicted in EFED'S initial screen using Fletcher values. However it is noted (especially for systemic pesticides), residues are found in food items of non target organisms. In addition, as was previously stated, compensation must be made for the condition of a field (the vegetation and invertebrates in the field at the time of application) and other routes of exposure besides ingestion of food. Mammals appear to be at risk both acutely and chronically from soil applications (particularly side dressing). The peak and mean residues in all media, except for invertebrates, exceed the the extrapolated 1 day LC50's (ranging for 2 to 12.7 ppm) and the chronic NOAEC (0.8 ppm). The Agency acknowledges that the extrapolated mammalian 1 day LC50s for disulfoton may exaggerate the actual acute risk.

Risks from foliar treatments

Tests were conducted by the Denver Wildlife Research Center (Evans et al. 1970; MRID

413591-01) to examine the feasibility of using foliar applications of disulfoton to control jackrabbits. Although few details of the tests were provided, some information was gathered on risks to wildlife from foliar applications of disulfoton.

Unspecified numbers of jackrabbits and cottontail rabbits were introduced into enclosed plots six hours after foliar application to barley plants (12 days post emergence) at rates of 1, 2, 5, or 25 lb ai/A. None of the cottontails died. No jackrabbit mortality was reported for the 1 lb ai/A application, but mortality was 100% at rates of 2, 5, and 25 lb ai/A. Additional tests were then conducted in enclosures planted with barley, alfalfa, wheat, or range grasses treated with a foliar application of 2 lb ai/A. Unspecified numbers of jackrabbits, cottontails, pigmy rabbits, domestic rabbits, wild and game farm pheasants, and mallards were introduced post-spray and exposed for anywhere from 0.5 to 13 days. Most or all jackrabbits died; but no mortality of other species was reported. Cholinesterase levels were reported as normal for cottontails, partridge, sage grouse, and pheasants.

Jackrabbits killed on spray plots in the pen tests also were fed to unspecified numbers of coyotes, dogs, golden eagles, a great-horned owl, and a red-tailed hawk. The number of jackrabbits consumed and their residue levels were not reported. Commercial mink also were fed digestive tracts, eviscerated carcasses, and uneviscerated carcasses of jackrabbits killed on 2 lb ai/A spray plots. All secondary consumers fed continuously for anywhere from 3 to 30 days with no mortality, although some ChE depression was noted. In conclusion, it appears that foliar applications up to 1.0 lb ai/A (unless applied 3 or more times at intervals of less than 10 days) will not result in mortality to non rodents.

Because dietary LC50 values for birds are in the range of 333 to 827 ppm, EFED initially concluded that residues at these levels are not likely to be a significant acute risk to birds. More will be said about the uncertainty of this conclusion in the risk characterization section. However there is a potential for chronic effects to birds since the NOAEC of 37 is exceeded by the peak residues found in crop foliage (44 ppm) and non crop vegetation (54 ppm) along the field borders. Given the fact that the LOAEC (78 ppm for bobwhite quail) is only slightly above the field residues there is uncertainty as to what duration of exposure will produce an adverse reproductive effect in birds. Furthermore some endpoints not examined under laboratory conditions could be negatively impacted under field conditions. These end points could include successful mating, nesting behavior or care of young. Adverse impact may occur either after a brief exposure to concentrations at the NOAEC level or a longer period at even lower levels.

ii. Risk from Granular Formulations of Disulfoton

Birds and mammals may be exposed to granular pesticides ingesting granules when foraging for food or grit. They also may be exposed by other routes, such as by walking on exposed granules or drinking water contaminated by granules. The number of lethal doses (LD50s) that are available within one square foot immediately after application (LD50s/ft^2) is used as the risk quotient for granular/bait products. Risk quotients are calculated for three separate weight class of animals: 1000 g (*e.g.*, waterfowl or medium sized mammal), 180 g (*e.g.*, upland gamebird or

small mammal), and 20 g (*e.g.*, songbird or very small mammal).

The acute risk quotients for broadcast applications of granular products are tabulated below.

Table 35. Avian and Mammal Acute Risk Quotients for Granular Products (Broadcast) Based on a Mallard LD50 of 6.54 mg/kg and a rat LD50 of 1.9 mg/kg.			
LD50s per animal are calculated by multiplying the weight of the animal (kg) by the LD50 in mg/kg.			
0.020 Kg (20 g)	bird LD50= 0.13mg per bird	Mammal LD50=0.038mg per mammal	
0.180 Kg (180 g)	bird LD50= 1.17 mg per bird	Mammal LD50= 0.34mg per mammal	
1.00 Kg (1000 g)	bird LD50= 6.54 mg per bird	Mammal LD50= 1.9mg per mammal	
Site/Application Method/Rate in lbs ai/A	Mammal or Bird Body Weight (g)	Mammal Acute RQ ¹ (LD50/ft ²)	Avian Acute RQ ¹ (LD50/ft ²)
Sorghum or Barley unincorporated			
1 (10.41 mg/sq ft)	20	273 a	79 a
1 (10.41 mg/sq ft)	180	30 a	8 a
1 (10.41 mg/sq ft)	1000	5 a	1.5 a
¹ RQ= mg per sq ft / LD50 per animal mg/sq ft = (app rate [lb ai per acre] * 453,590 [mg per lb]) / 43,560 [sq ft per acre] LD50 per animal = LD50 (mg/kg) * wt (kg) a=acute risk, restricted use and endangered species LOCs have been exceeded			

The results of this risk screen indicate that for broadcast applications of granular products, avian acute risk, restricted use, and endangered species levels of concern are exceeded at application rates equal to or above 1.0 lb ai/A.

The acute risk quotients for banded or in-furrow applications of granular products are as follows:

Table 36. Avian and Mammal Acute Risk Quotients for Granular Products (Banded or In-furrow) Based on a Mallard LD50 of 6.54 mg/kg and a rat LD50 of 1.9 mg/kg.						
LD50s per animal are calculated by multiplying the weight of the animal (kg) by the LD50 in mg/kg.						
0.020 Kg (20 g)	bird LD50= 0.13mg per bird	Mammal LD50=0.038mg per mammal				
0.180 Kg (180 g)	bird LD50= 1.17mg per bird	Mammal LD50= 0.34mg per mammal				
1.00 Kg (1000 g)	bird LD50= 6.54mg per bird	Mammal LD50= 1.9mg per mammal				
Site/method oz ai per 1000 ft of row	Band Width	% granules left on surface after soil incorp.	Exposure Concentration mg ai/ sq ft	RQ (LD50 / sq ft)		
				AVIAN	MAMMAL	
				20 gram animal	180 gram animal	1000 gram animal
Tobacco/ Banded / Incorporated						
6	0.5	15	51 avian	392a	43a	7a
(4.0 lb ai/A)			mammal	1342a	150a	26a
Potatoes/ In furrow / Incorporated						
3.45	0.5	1	1.9 avian	15a	1.6a	0.3b
(3.0 lb ai/A)			mammal	51a	5.7a	1.0a
Potatoes/ banded / Incorporated						
3.45	0.5	15	29 avian	225a	25a	4.5a
(3.0 lb ai/A)			mammal	763a	85a	15.2a
Vegetable (cole crops, etc.) /banded, incorporated						
1.1	0.5	15	9.36 avian	72a	8a	1.4a
(0.97 lb ai/A)			mammal	246a	27a	4a
¹ RQ= mg per sq ft / LD50 per animal mg/sq ft = [(oz ai per 1000 ft *28349 mg/oz)][% unincorporated (decimal) / bandwidth (ft) * 1000 ft] LD50 per animal = LD50 (mg/kg) * wt (kg) a= acute risk, restricted use and endangered species LOCs have been exceeded b=restricted use and endangered species LOCs have been exceeded						

Table 37. Avian and Mammal Acute Risk Quotients for Granular Products Based on a Mallard LD50 of 6.54 mg/kg and a rat LD50 of 1.9 mg/kg.

LD50s per animal are calculated by multiplying the weight of the animal (kg) by the LD50 in mg/kg.

0.020 Kg (20 g)	bird LD50= 0.13mg per bird	Mammal LD50=0.038mg per mammal
0.180 Kg (180 g)	bird LD50= 1.17mg per bird	Mammal LD50= 0.34mg per mammal
1.00 Kg (1000 g)	bird LD50= 6.54mg per bird	Mammal LD50= 1.9mg per mammal

Site/method lbs ai/acre	Band Width	% granules left on surface after soil incorp.	Exposure Concentration mg ai/ sq ft	RQ (LD50 / sq ft)		
				AVIAN	MAMMAL	
				20 gram animal	180 gram animal	1000 gram animal
Rasberries/ Banded / Incorporated						
11.75 oz ai/1000 ft (8 lb ai/A)	2	15	25 avian	192a	21a	3.8
			mammal	657a	73a	13a
Christmas trees /spot treatment broadcast (Sec 3) 3.75 oz prod/ tree with 1.5 inch diam at 4 ft.						
0.562 oz ai / tree(~2 sq ft) 1700 trees/A (59.7 lbs ai/A)		100	7966b avian	61276a	6808a	1218a
			mammal	209631a	23429a	4193a
Christmas trees /spot treatment broadcast (North Carolina 24 C) 5 gr product per tree						
0.026 oz ai / tree(~2 sq ft) 1700 trees/A (2.76 lbs ai/A)		100	368b avian	2830a	314a	56a
			mammal	9684a	1082a	193a
¹ RQ= mg per sq ft / LD50 per animal mg/sq ft =[(oz ai per 1000 ft *28349 mg/oz)] [% unincorporated (decimal) / bandwidth (ft) * 1000 ft] LD50 per animal = LD50 (mg/kg) * wt (kg) a=acute risk, restricted use and endangered species LOCs have been exceeded b= estimated by : (oz ai/tree)(28349 mg/oz)/2 sq ft/tree						

The disulfoton 15G (15% ai) granule is applied in cotton, grains, sorghum, peanuts, soybeans, tobacco, coffee, nonbearing fruit trees, pecans, vegetables, flowers, shrubs, trees, and ground cover. The results of this screening level risk assessment indicate that for both birds and mammals acute risk, restricted use, and endangered species levels of concern are exceeded for banded and in-furrow applications of granular products at registered maximum application rates equal to or above the lowest rate of 1.1 oz ai/1000 ft. Granules may be intentionally consumed as grit, mistaken for seeds, or may be ingested if attached to food items (e.g., earthworms). Even when granules are incorporated that does not preclude exposure to birds and mammals. Fisher and Best (1995) examined granule availability in Iowa cornfields and found that 6% of granules

applied in banded treatment were available on the soil surface, and granules were found in gizzards of 39% of 256 birds collected.

The LD50 per square foot screening approach for granulars can be refined by estimating how many disulfoton granules might be eaten by a bird in a day. Based on field counts and granule voiding experiments, 95% of the birds collected in Iowa cornfields were estimated to consume <18 granules per day. For the savannah sparrow (*Passerculus sandwichensis*), median consumption was 11 granules per day, with 5% of the individuals estimated to consume ≥ 23 granules/day (Fisher and Best 1995). A Di-Syston 15G granule weighs 0.083 mg (Balcomb et al. 1984, cited in MRID 413591-01) and thus contains 0.01245 mg ai. Eleven granules would contain 0.13695 mg ai. If an adult savannah sparrow weighs 20 g (Dunning 1984); then an individual consuming 11 granules in a day ingests 0.13695 mg ai which equates to 6.8475 mg ai/kg of its body weight. Assuming the LD50 for the sparrow is comparable to that for the red-winged blackbird (3.2 mg/kg), a sparrow ingesting 11 granules would be exposed to 2.14 times the theoretical dose lethal to 50% of the population. In a laboratory study, 10-20 granules of Di-Syston 15G were required to kill one out of five house sparrows (weighs 28 gr) and red-winged blackbirds (weighs 60 gr) respectively (Balcomb et al. 1984). Since the test level in the study were 1,5,10 and 20 granules; it is possible the actual number of granules required to kill a house sparrow was from 6 to 9 and 11 to 19 for the red-wing blackbird. Disulfoton granules may pose an even greater risk to mammals than to birds. Mammals may not intentionally eat granules, but granules can be consumed if attached to food items (e.g., soil invertebrates, seeds on the ground) or mistaken as food items (e.g., seeds). Assuming an LD50 of 1.9 mg/kg as for the female rat, a 20-g rodent would need to ingest only 0.038 mg ai (1.9 mg ai x 0.02 kg bw) to receive a dose lethal to 50% of the population. That dose could theoretically be obtained by eating 3 granules (0.038 mg ai/0.01245 mg ai/granule). The point to emphasize is that for any application described in the above table, at the time of application and until the granules disintegrate, there are sufficient numbers of unincorporated granules within a square foot to cause mortality -- especially to small birds and mammals..

Besides the intentional or inadvertent consumption of granules by birds and mammals, additional oral exposure to disulfoton is possible from consumption of soil during the disintegration of the granules. Estimates of soil ingestion by wildlife indicate that soil can comprise as much as 17-30% of the diet of species of some sandpipers and woodcock, presumably from consumption of soil organisms such as earthworms, which typically contain 20-30% soil (Beyer et al. 1994). Other species reported with soil in their diet include Canada geese (8% soil), raccoon (9% soil), armadillo (17% soil), wood ducks (11% soil), wild turkeys (9% soil), and white-footed mice (*Peromyscus leucopus*) fed foods containing either 0, 2%, 5%, and 15% soil ate equivalent amounts of food regardless of soil content (Beyer et al. 1994). Dermal contact of granules and contaminated soil also could increase an individual's exposure. Disulfoton is a Toxicity Category I pesticide for dermal toxicity (LD50 of 3.6 mg/kg for mammals), although the importance of dermal exposure of birds and mammals is uncertain in the field. Lastly, since disulfoton is systemic, non target organisms are exposed when ingesting invertebrates and plant foliage where granules have been applied.

A field study conducted in potato fields in Washington indicated that application of 15G granules can cause mortality of birds and mammals (MRID 410560-00). The fields were treated with two applications, each at a rate of 3 lbs ai/A -- one in furrow at planting and one side dressing 4 to 6 weeks later. Forty-one bird species and 8 mammal species were observed in the potato fields during the study. During transect searches, 32 casualties were reported. However,

based on the Agency's guidance for terrestrial field studies (EPA 1986), EFED concluded that the amount of area searched (5.5 acres) was not sufficient and that transects were too far apart for adequately locating carcasses. Moreover, only 2 of the 32 casualties were analyzed for disulfoton residues. Despite methodological problems with the study, EFED accepted it as a core study because it demonstrated mortality to wildlife inhabiting potato fields treated with 15G granules. Both in-furrow and banded applications indicate mortality may be expected to occur. The table below summarizes the residue levels resulting from the two soil incorporated applications of Di-Syston 15G.

Table 38. Mean and (maximum) total disulfoton residues resulting from two applications of Di-Syston 15 G

Application	Invertebrates (ppm)	Potato Foliage (ppm)
1 (in furrow)	0.14 (0.41)	n/a
2 (side dressing)	0.9 (5.2)	7.5 (25)

Although these residues are considerably below concentrations anticipated to cause mortality, when coupled with 1) other routes of exposure-- ingestion of granules and drinking from contaminated puddles -- and 2) hypersensitivity of some non targets organisms (i.e., jackrabbits and Swainson's hawks) some mortality is possible.

The application of granular formulations of disulfoton to raspberry and Christmas tree may include hand operation -- either dispensing or incorporation of granules; consequently there is a greater potential for granules to remain above ground. Although the labels for Christmas trees refers to incorporation or watering (within 48 hours) usually incorporation can not be conducted and April rainfall rather than irrigation is generally relied upon to activate the granules. Therefore the granules may remain intact and above ground for at least several days. There are several additional factors that confound the amount and type of exposure wild life may encounter from disulfoton on the granules. Number one, the distribution of the granules under the drip line will range from a teaspoon being fanned out in several square feet or else a side dressing along two sides of each row of trees. Number two, present cultural practices include leaving vegetation between the rows and under the drip line. This vegetation may obscure an animal's view of granules that have sifted through the cover or if moist, allow the granule to adhere to the leaf surface and be consumed by herbivores. Number three, after a rainfall the granules will dissolve and residues of disulfoton will appear in puddles and be taken up in vegetation. In light of these factors there is a high degree of uncertainty as to the degree of risk to wild life.

Christmas tree farms and the adjacent areas -- forests and or pasture -- provide excellent habitat for a great variety of wild life. The North Carolina Christmas Tree community has submitted numerous testimonials emphasizing the ever increasing numbers and diversity of wild life. This includes game animals such as turkey rearing young amidst the trees, song birds, rodents and foxes. Although this information is intended to suggest there is little or no negative impact from not only disulfoton, but other pesticides or cultural practices as well, the Agency would prefer to receive documented surveys or research before making a final determination.

Chronic Risk from Granular Formulations

Estimating long term exposure from granular applications is difficult, since the granules are not expected to remain in tact over extended periods. The chemical is expected to become distributed in the soil, as the granules dissipate.. However, given that disulfoton is chronically toxic to birds and mammals at low dietary concentrations, granular applications may contribute to chronic risk.

iii. Insects

Currently, EFED does not assess risk to nontarget insects. Results of acceptable studies are used for recommending appropriate label precautions. Disulfoton and its sulfoxide and sulfone metabolites are classified as highly toxic to the honeybee on an acute contact and oral basis, therefore, toxicity label language is required. Current labeling includes the appropriate bee toxicity warning statement.

B. Risk to Nontarget Freshwater and Estuarine Animals

The following table shows the specific toxicity values that were used in assessing acute and chronic risk to aquatic and marine organisms. Species that demonstrated ranges of sensitivity were used, not just the most sensitive species.

Table 39. Toxicity endpoints used in assessing risk of aquatic organisms for disulfoton			
Species *	Test Type	Results (ppb)	Source of Data
Freshwater Species			
Rainbow trout	Acute	LC50=1850	40098001
Bluegill	Acute	LC50=39	00068268
Channel catfish	Acute	LC50=4700	40098001
Rainbow trout	Early Life Stage	NOAEC=220	41935801
Bluegill	Early Life Stage**	estimated NOAEC=4.6	No study conducted
Water flea	Acute	EC50=13	00143401
Glass shrimp	Acute	EC50=3.9	40094602
Stonefly	Acute	EC50=5	40098001
Water flea	Reproduction	NOAEC=0.037	41935802
Marine Species			
Sheepshead minnow	Acute	LC50=520	40228401
Sheepshead minnow	Early Life Stage	NOAEC=16.2	42629001
Sheepshead minnow	Full Life Cycle	EC05=0.96***	43960501
Eastern Oyster	Acute	EC50=720	40228401
Mysid	Acute	EC50=100	40071601
Brown shrimp	Acute	EC50=15	40228401
Mysid	Life Cycle	EC05=2.35***	43610901
<p>* The species listed and used in risk assessment were selected from the toxicity data because they seemed to represent a distribution of sensitivity.</p> <p>** An early life stage study was not conducted with bluegill. The only freshwater fish chronic study was with rainbow trout. In the case of disulfoton, rainbow trout are significantly less sensitive than bluegill. So in an effort to translate this difference in sensitivity to the chronic risk assessment, a NOAEC for bluegill was calculated based on the ratio of acute toxicity. The lowest rainbow trout LC50=1850 ppb. The bluegill LC50=39. The ratio of trout to bluegill is 39/1850=0.021. 0.021 X the trout NOAEC of 220 ppb = 4.6 ppb. There is uncertainty in this value, since it is estimated, and not derived from an actual toxicity test.</p> <p>*** The study did not produce a NOAEC, however, the responses at the different concentrations were plotted used to estimate the concentration at which 5% effects would be expected, or an EC05.</p>			

Tier II estimated environmental concentrations (EECs) for a variety of disulfoton applications were calculated to generate aquatic exposure estimates for use in the ecological risk assessment. In the risk quotient tables below, both freshwater and marine species are included in the same table. The first table presents the acute risk quotients based on modeling, the second table presents the chronic risk quotients. The modeling represents exposure in a 1-hectare 2-meter deep enclosed pond receiving runoff and drift from a 10 hectare treated field. This scenario is considered relatively conservative, but may not represent the highest exposure in all cases, since water bodies can be shallower, and thus may have higher exposure potential. On the other hand, many water bodies are larger, and have flow that may dilute concentrations. Long-term exposures are especially uncertain when applied to flowing streams and rivers and estuaries and

may over-estimate the risk. However, not all estuaries involve rapid exchange of water, so these estimates are not automatically considered overly conservative for all estuaries..

Table 40. Acute risk quotients for freshwater and marine fish and invertebrates.

Use Pattern	EEC ppb	Acute risk quotients; peak EEC/LC50									
		Freshwater surrogate species						Marine surrogate species			
		fish			invertebrates			fish	invertebrates		
	LC50 (ppb)>	bluegill 39	rainbow trout 1850	channel catfish 4700	glass shrimp 3.9	stonefly 5	water flea 13	sheeps- head m. 520	brown shrimp 15	mysid 100	oyster 720
Tobacco soil 4.0 lb ai/a 1 app per yr incorp 2.5 inches	peak 26.7	0.6	<0.01	<0.01	6.8	5.3	2.0	0.05	1.7	0.2	0.03
Tobacco soil (granular) 4.0 lb ai/a 1 app per yr incorp 2.5 inches	peak 18.4	0.4	<0.01	<0.01	4.7	3.6	1.4	0.03	1.2	0.18	0.02
Potato foliar 1.0 lb ai/a 3 app at 14 day int. not incorporated	peak 15.0	0.3	<0.01	<0.01	3.8	3.0	1.1	0.02	1.0	0.1	0.02
Cotton soil 1.0 lb ai/a 3 app at 21 day int. not incorporated	peak 14.8	0.3	<0.01	<0.01	3.7	2.9	1.1	0.02	0.9	0.14	0.02
Barley foliar 1.0 lb ai/a 2 app at 21 day int. not incorporated	peak 9.2	0.2	<0.01	<0.01	2.3	1.8	0.7	0.01	0.6	0.09	0.01
Spring Wheat foliar 0.75 lb ai/a 2 app at 30 day int. not incorporated	peak 8.9	0.2	<0.01	<0.01	2.2	1.7	0.6	0.07	0.59	0.08	0.01
Potato soil 4.0 lb ai/a 2 app at 14 day int. incorp to 2.5 inches	peak 7.1	0.18	<0.01	<0.01	1.8	1.4	0.5	0.01	0.47	0.07	<0.01
Barley soil (granular) 0.83 lb ai/a 2 app at 21 day int. not incorporated	peak 7.1	0.18	<0.01	<0.01	1.8	1.4	0.5	0.01	0.47	0.07	<0.01

Risk quotients exceeding the acute risk LOC of 0.5 are **bolded**

The LOC for restricted use is 0.1

The LOC for endangered species is 0.05

The screening assessment results indicate that except for the highest application to tobacco, the acute risk LOC has not been exceeded for fish. Estuarine fish appear to be a far less risk than freshwater fish. On the other hand, the RQs for all modeled uses exceed the acute risk LOC for

fresh water invertebrates. Although two of the three test species of estuarine invertebrates did not suggest risk, based on the brown shrimp, estuarine invertebrates are at acute risk from all modeled crops. Especially for estuarine invertebrates there is uncertainty as to the degree of the acute risk.

Table 41. Chronic risk quotients for freshwater and marine fish and invertebrates.

Use Pattern	EEC ppb	Chronic risk quotients; ave. EEC/NOAEC or EC05					
		Freshwater surrogate species			Marine surrogate species		
		fish		invertebrates	fish		invertebrates
	NOAEC (ppb)→	bluegill 4.6	rainbow trout 220	water flea 0.037	sheepshead life cycle 0.96	Sheepshead early life st. 16.2	Mysid life cycle EC05= 2.35
Tobacco soil 4.0 lb ai/a 1 app per yr incorp 2.5 inches	21-d 17.9 60-d 9.9	2	<0.1	483	10.3	0.6	7.6
Tobacco soil (granular) 4.0 lb ai/a 1 app per yr incorp 2.5 inches	21-d 12.5 60-d 6.7	1.4	<0.1	337	6.9	0.4	5
Potato foliar 1.0 lb ai/a 3 app at 14 day int. not incorporated	21-d 10.4 60-d 6.9	1.5	<0.1	281	7.1	0.4	4.4
Cotton soil 1.0 lb ai/a 3 app at 21 day int. not incorporated	21-d 8.0 60-d 4.9	1	<0.1	216	5.1	0.4	3.4
Barley foliar 1.0 lb ai/a 2 app at 21 day int. not incorporated	21-d 5.9 60-d 3.7	0.8	<0.1	159	3.8	0.2	2.5
Spring Wheat foliar 0.75 lb ai/a 2 app at 30 day int. not incorporated	21-d 4.5 60-d 2.6	0.5	<0.1	121	2.7	0.1	1.9
Potato soil 4.0 lb ai/a 2 app at 14 day int. incorp to 2.5 inches	21-d 4.3 60-d 2.3	0.5	<0.1	116	2.4	0.1	1.8
Barley soil (granular) 0.83 lb ai/a 2 app at 21 day int. not incorporated	21-d 5.4 60-d 3.8	0.8	<0.1	145	3.9	0.2	2.2

Risk quotients exceeding the chronic risk LOC are **bolded**

Risk quotients for invertebrates and fish are based on 21 and 60 day EECs respectively

Both fish and invertebrates are likely to experience chronic effects based on modeled EECs. Freshwater invertebrates are at much greater risk than fish or estuarine invertebrates.

Risk to Freshwater Organisms from the use of Disulfoton 15 on Christmas Trees in North Carolina

The use of Disulfoton 15 G in Christmas tree farms at this time can not be modeled for potential surface water contamination. EFED assumes the estimated concentration for the North Carolina 24 (c) use pattern -- 2.75 lbs ai/ A unincorporated -- may be similar to the values for the single 4.0 lb ai/A incorporated application of granular disulfoton to tobacco. Based on this assumption there is acute risk to aquatic invertebrates and chronic risk to freshwater fish and aquatic invertebrates. Since this preliminary screen of the 24(c) exceeds levels of concern, the Sec 3 use at 59.7 lbs ai/A would exceed (perhaps by 20 fold) the same levels of concern for aquatic life and the acute risk for fish as well. However, even if the receiving body of water was a pond (as was modeled for tobacco) this assumption has uncertainty because although the Christmas tree use pattern has a lower rate and current cultural practices recommend maintaining vegetation under the trees and between the rows; nevertheless the material is not incorporated. Therefore while the first two conditions may reduce the estimated concentrations below those for tobacco, the third condition may increase the concentrations.

The North Carolina Christmas tree industry has provided information that has contributed to a refinement of EFED's risk assessment for aquatic organisms from Christmas tree farming. Firstly, the primary and nearly exclusive use site for Disulfoton 15 G on Christmas trees throughout the United States is on Fraser fir grown in 6 counties in Western North Carolina, thereby localizing the exposure and precluding any estuarine exposure. Secondly, the primary aquatic sites adjacent to tree farms are streams, not ponds. Residues in these streams will be lower and of shorter duration than would be expected for a pond. Thirdly, two rapid assessment macro invertebrate surveys of streams in the Western region of North Carolina have been submitted. The following is a brief discussion of those results.

In the 1998 study conducted by the North Carolina Department of Environmental Health and Natural Resources (DEHNR), 8 of 11 streams were sampled once in May (presumably after the April/May application of disulfoton) at one location. The 3 other streams were sampled a second time in August as a means to correct for likely seasonal changes in the species composition of Ephemeroptera, Plecoptera and Trichoptera (EPT). These three Orders of invertebrates are considered to be sentinel species indicative of overall water quality.

In spite of some concerns such as the mixed influence of cattle or development along with Christmas tree farms and the preference for a more rigorous study design (i.e. residue analysis and more frequent sampling) the Agency considered the survey's utility in light of several factors: an on-site visit in June 2000; the support for the protocol as described in the EPA publication: EPA 841-B-99-002; the nation wide use of disulfoton on Christmas trees is primarily in this region where it has been used for 20 years and the submission of a second survey conducted from December 1998 through mid to late summer 1999.

The second survey examined 5 sites – each consisting of an area adjacent or downstream from a Christmas tree farm paired with its own reference site (either a station on the same stream, but above the tree farm or a second stream. Quantification - included the total number of insects and the break out (expressed as a % of insects) for mayflies, stoneflies, caddisflies, riffle beetles and “other” insects. A species list for mayflies, stoneflies and caddisflies along with an index of their sensitivity and the dates collected was provided for 3 of the 5 sites. Data for each of the reported 3 pairs of sites were analyzed using ANOVA.

Unlike the DEHNR survey where various communities (leaf packs, riffles, banks and large rocks and logs) were sampled, only the riffle community was sampled. Like the DEHNR survey, no residue analysis was performed for any pesticide including disulfoton. Again the researcher made the point that the protocol seeks to detect whether an impact is occurring due to the combination of numerous influences without quantifying the degree of exposure to a specific chemical(s).

The Agency concurs with the investigators that when implementing (but not limited to) conservation measures such as establishing ground cover throughout the farm, constructing and maintaining the fewest number of roads and bridges, creating a riparian zone to include vegetation and trees and employing Integrated Pest Management practices, there appears to be “...little negative effect on the fauna of adjacent streams...” The slight negative effect that was observed seemed to impact stoneflies (Plecoptera) more than the two other orders– caddisflies (Trichoptera) and mayflies (Ephemeroptera) - that were the focus of the survey.

In summary, the two surveys suggest that when conservation measures associated with Christmas tree farming in the Western counties of North Carolina are implemented, there may be only slight, short term impact to aquatic macro invertebrates from disulfoton use. Aquatic macro invertebrates appear to have the capacity to recover from any impact that could be caused by disulfoton use on Christmas trees in Western North Carolina.

C. Exposure and Risk to Nontarget Plants

Although Tier I terrestrial and aquatic plant testing is required for disulfoton due to label phytotoxicity warnings, no data on plant toxicity has been submitted at this time. Therefore, the risk to nontarget plants cannot be assessed.

5. Endangered Species

The following endangered species LOCs have been exceeded for disulfoton: avian acute, avian chronic, mammalian acute, mammalian chronic, freshwater fish acute, freshwater invertebrate acute, freshwater invertebrate chronic, marine/estuarine fish acute, marine/estuarine fish chronic, marine/estuarine invertebrate acute, and marine/estuarine invertebrate chronic. Endangered terrestrial, semi-aquatic and aquatic plants also may be affected, based on label statements indicating phytotoxicity.

The OPP Endangered Species Protection Program (ESOP) is developing ways to protect endangered species from hazardous pesticides. Limitations on the use of disulfoton will be required to protect endangered and threatened species, but these limitations have not been defined and may be formulation specific. EPA anticipates that a consultation with the Fish and Wildlife Service may be conducted in accordance with the species-based priority approach described in the ESOP. After completion of consultation, registrants will be informed if any required label modifications are necessary. Such modifications would most likely consist of the generic label statement referring pesticide users to use limitations contained in county Bulletins.

6. Disulfoton Incident Reports

There are both bird and fish kills reported for disulfoton. The following are summaries of incidents reports available to the Agency.

BIRD INCIDENTS:

1. Young County, TX, 6/18/93. Eighteen Swainson's hawks were found dead and one found severely disabled in a cotton field. The cotton seed had been treated with disulfoton seed treatment prior to planting, about 10 days before the birds were discovered. According to field personnel, no additional applications of organophosphorus or carbamate pesticides had been made in the vicinity of the field. Autopsies revealed no signs of trauma or disease. Laboratory analysis of the birds revealed insect material in the gastrointestinal tracts. Residue chemistry analysis of this material indicated the presence of disulfoton (approximately 7 ppm); no other organophosphorus or carbamate insecticides were present. Apparently, the hawks had fed on insects, which had been feeding on the young cotton plants. The systemic nature of the pesticide appears to have resulted in plant residues, which were then taken up by the insects, at levels high enough to cause mortality in the hawks. This may be the first documented incident of this type of exposure in a captor species. (L.Lyon, Div. of Environmental Contaminants, U.S. Fish and Wildlife Service, Arlington, VA. Presented at the SETAC 18th annual meeting, San Francisco, CA, 1997). The Agency has been able to confirm the incident through personal communication with Stephen Hamilton, the Special Agent of the U.S. Fish and Wildlife in charge of the investigation, who stated there was no evidence of misuse.

2. Sussex County, DE, 4/26/91. Nine American robins found dead following application of granular disulfoton at a tree nursery. Corn and soybeans were also in the vicinity. No

laboratory results were obtained. Certainty index is probable for disulfoton. (Incident Report No. I000116-003).

3. Puerto Rico, 1/24/96. Six grackles fell dead from a tree in the yard of a private residence. A dead heron and a dead owl were also found in the vicinity. The use site and method were not reported. Birds had depressed acetyl cholinesterase. Residue analysis on gut contents of one of the grackles found disulfoton residues of 12.37 ppm wet weight. Certainty index of this incident is highly probable for disulfoton. (Incident Report No. I003966-004).

FISH INCIDENTS

1. Onslow County, NC, 6/22/91. A fish kill occurred in a pond at a private residence. The pond received runoff from a neighboring tobacco field. Analysis of the water in the pond revealed the presence of disulfoton and several other pesticides, including endosulfan. Disulfoton sulfoxide was found in the water at a concentration of 0.32 ppb. Endosulfan had the highest concentration (1.2 $\mu\text{g/L}$), and is toxic to fish, but disulfoton cannot be ruled out as a possible cause of death. No tissue analysis was conducted. The certainty index of this incident for disulfoton is “possible.” (Incident Report No. B0000216-025).

2. Onslow County, NC, 4/29/91. A fish kill occurred in a pond, which was adjacent to a tobacco field and a corn field. Rain followed the application of pesticide, and more than 200 dead fish were found floating in the pond. Water and soil samples were collected within a week after the incident. Several organophosphorus pesticides, as well as atrazine and napromide, were found in all soil samples taken from around the pipe that ran from the field to the pond, but none of the samples contained detectable disulfoton. The pesticide applicator failed to follow packaging guidance on safe handling of the pesticides. Additionally, the corn and tobacco fields were 62-82 feet uphill from the pond, which violates the requirement that these pesticides not be applied within 140 feet of a waterway. The certainty index for this incident is “unlikely” for disulfoton (Incident Report No. I000799-004).

3. Johnston County, NC, 6/12/95. A fish kill occurred in a commercial fish pond. Crop fields nearby had been treated with pesticides. Water, soil and vegetation samples were taken and analyzed for a variety of pesticides. Disulfoton, as well as several other pesticides was found in the samples. The level of disulfoton in the vegetation samples was 0.2-2.5 ppm. The certainty index for this incident is “possible” for disulfoton. (Incident Report No. I003826-002).

4. Arapahoe County, CO, 6/14/94. A fish kill occurred following application of Di-Syston EC. to wheat, which was followed by a heavy rain. Water samples collected contained disulfoton sulfoxide at levels of 29.5-48.7 ppb, and disulfoton sulfone at 0.0199-0.214 ppb. The wheat field was located several miles from the pond. The volume of run off water raised the level of the pond fifteen feet. In addition to the rapid rise of the water level there was a large mass of sediment and vegetation that may have resulted in a severe drop in the Biological Oxygen Demand levels. The certainty index for this incident is “possible” for disulfoton. (Incident Report No. I001167-001).

Some of these incident reports tend to support the conclusions of the risk screens indicating LOCs for acute risk are exceeded.

Risk Characterization

A. Characterization of the Fate and Transport of Disulfoton

i. Water Exposure

(a) Surface Water

Disulfoton is likely to be found in runoff water and sediment from treated and cultivated fields. However, the fate of disulfoton and its degradates once in surface water and sediments, and the likely concentrations therein, cannot be modeled with a high degree of certainty since data are not available for the aerobic and anaerobic aquatic degradation rates. Surface water concentrations of disulfoton and total disulfoton residues were estimated by using PRZM3 and EXAMS models using several different scenarios (barley, cotton, potato, tobacco, and spring wheat). The large degree of latitude available in the disulfoton labels also allows for a wide range of possible application rates, total amounts, application methods, and intervals between applications. Considering the relatively rapid rate of microbial degradation in the soil (<20 day aerobic soil metabolism half-life) and direct aquatic photolysis, disulfoton parent may degrade fairly rapidly in surface water. However, peak concentrations of disulfoton in the farm pond appear capable of being quite high, with 1-year-in 10 peak surface water concentrations of 7.14 to 26.75 $\mu\text{g/L}$ and 90-day concentrations of 1.73 to 6.87 $\mu\text{g/L}$ for the parent compound. The mean EECs of the annual means of disulfoton ranged from 0.21 to 1.14 $\mu\text{g/L}$. Although there is a lack of some environmental fate data for the degradates, the assessment suggests that the degradates will reach higher concentrations than the parent because they are more persistent and probably more mobile. The estimated peak concentrations for the total disulfoton residues in the farm pond ranged from 15.43 to 58.48 $\mu\text{g/L}$, 90 day average ranged from 12.20 to 35.30 $\mu\text{g/L}$, and the mean of the annual means ranged from 3.89 to 9.32 $\mu\text{g/L}$. Water samples collected at the site of a fish kill in Colorado contained D. sulfoxide at levels of 29.5-48.7 $\mu\text{g/L}$, and D. sulfone at 0.0199-0.214 $\mu\text{g/L}$. The aerobic soil metabolism studies show that the maximum sulfoxide residues are about 58 percent of total radioactive material, thus, the sulfoxide concentrations suggest that parent disulfoton concentrations could range from 50.8 to 83.9 $\mu\text{g/L}$. The ratio of the disulfoton sulfoxide concentration to the average maximum disulfoton concentration was higher (74%) in the microcosm study (MRID # 4356501) than in the soil residues (58%).

The estimated drinking water concentrations (EDWC) for parent disulfoton and total disulfoton residues were also determined using the IR and PCA concepts. The peak concentrations of disulfoton in IR appear capable of being quite high, with 1-year-in 10 peak surface water concentrations of 7.13 to 44.20 $\mu\text{g/L}$ and annual mean concentrations of 0.43 to 2.77 $\mu\text{g/L}$ for the parent compound. The mean EECs of the annual means of disulfoton ranged from 0.23 to 1.31 $\mu\text{g/L}$. Although there is a lack of some environmental fate data for the degradates, the assessment suggests that the degradates will reach higher concentrations than the parent because they are more persistent and probably more mobile. The estimated 1-in-10 year peak concentrations for the total disulfoton residues in the IR ranged from 20.83 to 104.92 $\mu\text{g/L}$ and annual mean ranged from 5.10 to 16.25 $\mu\text{g/L}$, and the mean of the annual means ranged from 2.55 to 10.42 $\mu\text{g/L}$. These values will also be highly affected by the value selected for PCA.

Surface-water samples were collected in a study to evaluate the effectiveness of Best Management Practices (BMP) in a Virginia watershed. Approximately half of the watershed is

in agriculture and the other half is forested. The detections of parent disulfoton in surface-water samples ranged from 0.037 to 6.11 µg/L and fell within an order of magnitude with the estimated environmental concentrations (EECs) obtained from the PRZM/EXAMS models.

Surface-water monitoring by the USGS in the NAWQA (USGS, 1998) project found relatively few detections of disulfoton in surface water with a maximum concentration of 0.060 µg/L. As noted above disulfoton degradates were reported in surface water, when a rainfall event occurred following application to wheat, where fish kills occurred; pesticide residue concentrations ranged from 29.5 to 48.7 µg/L for D. sulfoxide and 0.02 to 0.214 µg/L (Incident Report No. I001167-001).

A search of the EPA's STORET (10/16/97) data base resulted in the identification of disulfoton residues at a number of locations. Often the values ranged from 0.01 to 100.0 µg/L with most of the values reported as "actual value is less than this value." Thus, when a value of 100.00 µg/L is reported, it is not known how much less than 100.0 µg/L the actual value is known to be less. Thus there is considerable uncertainty surrounding some of the data in STORET.

(b) Ground Water

The SCI-GROW (Screening Concentration in Ground Water) screening model developed in EFED was used to estimate disulfoton concentrations in ground water (Barrett, 1999). SCI-GROW represents a "vulnerable site", but not necessarily the most vulnerable conditions, treated (here) with the maximum rate and number of disulfoton applications, while assuming conservative environmental properties (90 percent upper confidence bound on the mean aerobic soil half-life of 6.12 days and an average K_{oc} value of 551 mL/g). The maximum disulfoton concentration predicted in ground water by the SCI-GROW model (using the maximum rate 4 lb. a.i./ac and 2 applications - potatoes) was 0.05 µg/L. The maximum total disulfoton residue concentration predicted in ground water by the SCI-GROW model for the same scenario is 3.19 µg/L (except 90 percent upper bound on mean half-life of total residues is 259.6 days).

Ground water monitoring data generally confirms fairly rapid degradation and low mobility in soil, because of the relatively low levels and frequency of detections of parent disulfoton in ground water. There were no ground-water detections of parent disulfoton in the USGS NAWQA (USGS, 1998) with a limit of detections of 0.01 or 0.05 µg/L, depending upon method.

Most of the studies recorded in the PGWDB (USEPA, 1992) also reported no disulfoton detections. Disulfoton residues ranging from 0.04 to 100.00 µg/L were reported for studies conducted in Virginia (0.04 to 2.87 µg/L) and Wisconsin (4.00 to 100.00 µg/L). Of specific interest are areas where the concentrations of parent disulfoton reported in the studies (VA and WI) exceeded the estimate of 0.05 µg/L obtained from EFED's SCI-GROW (ground-water screening model) model. It should be noted that the Wisconsin data received some criticism which influences the certainty of these detections, no such criticisms or limitations exist for the Virginia study.

The major issues, concerning the Wisconsin study (Central Sands) were that the study may not have followed QA/QC on sampling and the failure of follow-up sampling to detect disulfoton residues in ground water as suggested by Holden (1986), have been considered by EFED in the

ground-water quality assessment. The Central Sands of Wisconsin are known to be highly vulnerable to ground-water contamination. There are regions within the United States that have conditions that are highly vulnerable to ground water contamination and regularly have pesticides detected in ground water which far exceeds values seen elsewhere. Several of these areas are well documented, e.g., Long Island, Suffolk County, NY and Central Sands in WI. Although, some questions have been levied against the disulfoton detections in Wisconsin, the occurrence of disulfoton at the levels reported cannot be ruled out.

There were no detections of disulfoton, disulfoton sulfoxide, and disulfoton in the ground-water monitoring study conducted in North Carolina. Efforts were made to place the wells in vulnerable areas where the pesticide use was known, so that the pesticide analyzed for would reflect the use history around the well. Seven Christmas tree, one wheat, and two tobacco growing areas were sampled for disulfoton. Limitations of the study include that sites were sampled only twice and the limits of detections were high (e.g., $> 1.0 \mu\text{g/L}$) for some of disulfoton analytes. Uncertainties associated with the study include whether two samples from eight wells are adequate to represent the ground-water concentrations of disulfoton residues, did DRASTIC correctly identify a site's vulnerability, and were the wells placed down-gradient of the use areas.

The SCI-GROW model represents a "vulnerable site", but not necessarily the most vulnerable. Several things should be considered. First, the Virginia and Wisconsin monitoring studies were probably conducted in areas vulnerable to ground-water contamination. The level of certainty with respect to vulnerability is probably greater for Wisconsin (relatively less uncertainty) than for Virginia (relatively more uncertainty). The occurrence of preferential flow and transport processes has been also noted in Wisconsin (and is also possible in Virginia) and may (speculation) have contributed to the "high" concentrations (especially in WI) when the initial sampling occurred, but not necessarily in the follow-up sampling). The knowledge concerning the disulfoton use in areas in association with the wells is not well known (high uncertainty). Some notable limitations of modeling and monitoring are presented elsewhere in this document

(c) Drinking Water

The estimates of disulfoton residues in drinking water in an index reservoir adjusted by percent crop area in the watershed is using the coupled PRZM/EXAMS models. The Agency recommends that the 1-out-of-10-year peak values be used the acute surface drinking water level for parent disulfoton, and for chronic levels use either the 90-day and annual average. The maximum values are: 44.20, 2.77, and $1.31 \mu\text{g/L}$ or the peak, 90-day mean, and long term mean, respectively. For the total disulfoton residues the peak, 90-day mean, and long term mean are 104.92, 53.47, and $10.42 \mu\text{g/L}$. The EDWCs for both parent disulfoton and TDR exceed the DWLOC values estimated by the Agency. The EDWCs values for the parent disulfoton have less uncertainty than the total residue, because there is more certainty surrounding the "estimated" aerobic aquatic metabolism half-life for the estimated aerobic aquatic half-life for the total disulfoton residues. It is recommended that the Virginia data be considered in the "quantitative" drinking water assessment for ground water exposure. The Wisconsin data should be noted and addressed more qualitatively. Highly vulnerable areas, such as the Central Sand Plain, do not represent the entire use area and can probably be better mitigated or managed a local or state level. Specifically, it is recommended that the $2.87 \mu\text{g/L}$ be used for acute and chronic exposure from ground water. Based upon the fate properties of

disulfoton, the sulfoxide and sulfone degradates (more persistent and probably more mobile) have a greater probability of being found in ground water. It is likely that ground water and surface water monitoring study (ies) may be required to better assess the potential exposure from the degradates (and also parent) in addition to the additional fate data requirements.

The registrant disagreed with aquatic dissipation half life of 259 days for total disulfoton residues and cites a microcosm study (MRID 43568501) and an open literature study (La Corte et al., 1994; 1995) which they believe provide data relevant to aquatic dissipation. However, aerobic and anaerobic aquatic metabolism studies which could provide valid model inputs for the degradates disulfoton sulfone and disulfoton sulfoxide have not been submitted. Although the registrant provided the Agency with additional information concerning the fate of disulfoton residues in water under controlled artificial conditions (MRID 43568501 and LaCorte et al., 1995), this information is limited and cannot be used for model inputs. Specifically, these studies provide information concerning the combined effects of hydrolysis, photolysis, and metabolism, with photodegradation contributing significantly to the dissipation. (An input value for photodegradation was included in the modeling, so this process was incorporated into the dissipation of disulfoton as simulated in the modeling.) Model input values should be derived from studies which isolate a given process, i.e., aquatic metabolism, from other routes of dissipation which are considered separately by the model. EFED believes it is not appropriate to use dissipation values, such as those provided in the studies cited by the registrant, as inputs for models which are intended to simulate dissipation from a variety of individual processes.

The 259 day half-life was the upper 90% confidence bound on the mean of total residue half-lives in aerobic soil metabolism studies (MRIDs 40042201, 41585101, 43800101). Because there are no studies for individual degradates from which model inputs can be derived, and because these degradates are of toxicological concern, it is appropriate to use total residue data from the existing studies. The assessment could be refined if studies for the individual degradates were conducted and model inputs could be derived from these studies. The aerobic soil metabolism half-life is used to estimate the aerobic aquatic half-life when aerobic aquatic data are not available. OPP has noted that this contributed to the uncertainty of the water assessment.

EFED thinks that it is appropriate to use total residues to estimate exposure when there are toxic degradates and when data are not available for the individual degradates. This will contributed to the uncertainty of the water assessment.

B. Characterization of risk to nontarget species from Disulfoton

Birds: Birds: Acute risk to birds is predicted especially for use patterns involving the 15 G formulation. All modeled application rates and methods for the 15 G formulation exceed the acute risk level of concern for birds, regardless of size. Robins were reported to have been killed following the application of a disulfoton granular product to a tree nursery. Carcasses were found during terrestrial field testing of disulfoton on potatoes, confirming the presumption of acute risk to birds. Since disulfoton is a systemic pesticide, the granular formulations can result in exposure through food items due to uptake by the plant tissues in addition to direct exposure to any unincorporated granules.

Foliar applications of liquid formulations present the greatest risk to herbivorous birds. Based on the results of field studies, the residue levels on sampled invertebrates are well below those predicted by EFED's models, consequently insectivores did not appear to be at risk. However, there is field evidence suggesting that some species are extremely sensitive to disulfoton such that even low concentrations caused mortality. The Swainson's hawk kill appears to be the result of consuming grasshoppers. The hawks crop contents were analyzed and contained residues around 8 ppm. Finally, live blue jays collected 6 to 7 hrs after a pecan orchard was sprayed at 0.72 lbs ai/A had brain cholinesterase inhibition from 32 to 72% (White et al. 1990). Although it is unknown whether these birds would eventually die, Ludke et al. 1975 suggest that inhibition >50% in carcasses is evidence that death was caused by some chemical agent. Furthermore, it should be recognized that these birds were not only feeding on contaminated food, but also were impacted by dermal and inhalation exposure.

Ground applications of liquid formulations to soil, even at 4.0 lb ai/A would not be expected to cause mortality to birds. Field studies have demonstrated that residue concentration within food items -- vegetation, invertebrates and seeds -- in or on the edge of fields are well below those used in screening level assessments and empirically derived from aerial applications. However, in light of the points made in the previous paragraph, some mortality is possible given the possible multiple routes of exposure and hypersensitivity of some species.

Chronic risk to herbivorous birds are predicted from exposure to disulfoton when assuming birds are exposed to peak residues for a short period of time or average Fletcher maximum residues for longer periods. Based on reduced hatchling weight, the NOAEC is 37; both for bobwhite quail and mallard duck. Foliar applications and aerially applied soil sprays are estimated to result in 30 day average residues (based on maximum Fletcher values) on vegetation exceeding the avian chronic level of concern for application rates equal or greater than a single application of 1 lb ai/A. A residue monitoring study for Di-Syston 8E in potatoes showed the peak residues on vegetation was 105 ppm after the initial application and 152 ppm following a second application 6 to 10 days later. In the same study, the means of the 3 applications for vegetation in and adjacent to fields were 41 and 14 ppm respectively. The upper bound 95% mean for the vegetation adjacent to the fields was 71 ppm. Therefore even empirically derived residues suggest that the chronic LOC is exceeded on foliage, but not invertebrates for a short time following aerial applications. It is anticipated that since the sulfone and sulfoxide degradates of disulfoton were similar in acute toxicity to parent disulfoton they would have similar chronic NOAECs. These degradates extend the time that total disulfoton residues are available for consumption. Since many of the applications of disulfoton occur in the spring, overlapping the breeding season for most bird species, there is the potential for significant reproductive impacts.

Mammals: Acute risk to mammals is expected for use patterns involving the 15 G formulation. All modeled application rates and methods exceed the acute risk level of concern for mammals, regardless of the mammals' size. Small mammal carcasses were found during terrestrial field testing of disulfoton on potatoes, confirming the presumption of acute risk to mammals. Since disulfoton is a systemic pesticide, the granular formulations can result in exposure through food items due to uptake by the plant tissues in addition to direct exposure to any unincorporated granules.

Applications of the liquid formulations especially by air can result in mammals being exposed to multiple routes of exposure --dermal, inhalation, drinking contaminated water as well as

ingestion of contaminated food items. The persistent sulfone and sulfoxide degradates are also toxic to mammals, thereby increasing the potential risk from the application of disulfoton. The registrant has suggested that mammals as well as birds can consume an equivalent of 2 to 3 LD50's as part of their diet and not be adversely effected. Although this may be true for a population of laboratory test animals, individuals will vary in their sensitivity and can die as a result of inability to avoid predation, secure prey or thermoregulate. Numerous pen studies were conducted with cottontail and jack rabbits exposed to single applications ranging from 1 to 25 lbs ai/A. While no mortality occurred to cottontails, at the 2 lb ai/A rate and above jackrabbits suffered 100% mortality. Secondary poisoning did not occur when the jackrabbit carcasses were fed to a number of avian and mammalian carnivores. The apparent difference between the pen study results and the acute mortality predicted in the risk assessment screen is largely due to the possibility that the calculated 1 day LC50s (ranging from 2 to 12.7 ppm) discounts the rapid metabolism of disulfoton. However, using the demeton LC50 of 320 ppm with its wide ranging confidence interval (0 to infinity) also adds uncertainty to the question of disulfoton's acute risk to mammals.

Chronic risk to mammals is predicted. As was previously discussed in the above acute and chronic sections for birds, there are several reasons why small mammals are likely to be at even greater risk, not the least of which is the extremely low NOAEC of 0.8 ppm. All modeled and empirically derived residues for all sites exceed the chronic risk level of concern for mammals. Finally, the persistence of the sulfone and sulfoxide degradates, which are also toxic to mammals, increases the likelihood of chronic risk to mammals.

Non-target Insects: Disulfoton and its sulfoxide and sulfone degradates are moderately to highly toxic to bees, however a residual study with honey bees indicated no toxicity for applications up to 1 lb ai/A.

Freshwater Fish: Most of the modeled use patterns did not exceed acute risk levels of concern for freshwater fish. Only the two soil applications at 4.0 lb ai \A of the liquid formulation exceeded acute risk. All other scenarios exceeded the restricted use and endangered species levels of concern. There is, however, a large amount of variation in freshwater fish species' sensitivity to disulfoton, as evidenced in the toxicity data table. The microcosm study included bluegill sunfish. Following the last application of 30 ppb, 10% of the fish died. Several kills of freshwater fish have occurred from applications of disulfoton to different crops-- both as registered uses as well as from misuse.

Chronic risk to freshwater fish may occur from uses where single application rates are equal to 4 lb ai/a and from 3 applications of 1 lb ai/A.. The single freshwater fish species (rainbow trout), for which chronic toxicity data was available, demonstrates significantly less sensitivity to disulfoton than several other species (bluegill sunfish, bass, guppy). Therefore, an estimated chronic NOEC value was calculated using the chronic to acute ratio for the rainbow trout, as described earlier. Based on the estimated chronic NOAEC for bluegill, chronic effects would occur from the present uses on tobacco, foliar treatments of potatoes and repeated soil treatments of cotton. Christmas tree plantations were not modeled, however the high application rate (possibly 47 lbs ai/A) and sloped land may be a potentially risky site.

Freshwater Invertebrates: All modeled crop scenarios exceeded the acute risk level of concern, but the highest risk quotients were less than 10. Again, the risk is further increased due to the toxicity and persistence of the degradates of disulfoton. Microcosm study results

indicated that there was recovery of most phyla examined at 3 ppb and long term impacts for most phyla at 30 ppb. Therefore 10 ppb is probably a concentration where short term effects will occur, but recovery can be anticipated.

Chronic risk to freshwater invertebrates is predicted to from the use of disulfoton. All of the modeled crop scenarios greatly exceeded the level of concern, sometimes by a factor of several hundred. Invertebrate life-cycle testing with disulfoton shows that it impacts reproductive parameters (number of young produced by adults) in addition to survival and growth. The 21 day average EECs for the modeled sites ranged from 4.3 to 17.9 ppb. For the most part these EECs are within the range where recovery was occurring in the microcosm. However there is uncertainty as to how much more reliable the microcosm may be as a predictor of safety.

Estuarine and Marine Fish: Although acute and restricted risk levels of concern were not exceeded for estuarine and marine fish, the endangered species level of concern was exceeded for several of the modeled crop scenarios (cotton, potatoes and wheat). As was note among the freshwater fish, there can be substantial species differences in sensitivity to disulfoton. Therefore, it is possible that the single marine/estuarine fish species tested (Sheepshead minnow) does not fully represent the true range of sensitivity found in a marine or estuarine ecosystem, and this assessment may therefore underestimate the true risk to marine/estuarine fish. There is also some uncertainty in using the PRZM/EXAMS EECs derived for ponds to predict exposure to marine/estuarine organisms. The scenarios modeled are based on hydrologic data for freshwater habitats. The exposure in a marine or estuarine habitat may be higher or lower than that predicted for a freshwater habitat, resulting in higher or lower risk to marine/estuarine organisms.

Chronic risk to estuarine and marine fish is predicted from the use of disulfoton. Both early life-stage and full life-cycle testing demonstrated a variety of effects at low levels of disulfoton. Risk quotients based on the early life-stage toxicity endpoint exceeded the level of concern for cotton, potatoes and tobacco. The highest risk quotients were based on numerous life-cycle toxicity endpoints --fecundity, hatching success and growth; consequently the chronic level of concern was exceeded for all modeled scenarios. Estuarine fish spawning in the upper reaches of tributaries of bays would be a greatest risk. However the likelihood of this risk is uncertain for several reasons: 1) the required time the adults must be exposed to disulfoton in order for their reproductive systems to be effected and 2) the residency time of disulfoton residues in tidal or flowing water. Even if adults are effected after an exposure of only a week, disulfoton may be moved out of an area within several days.

Estuarine and Marine Invertebrates: Three of the five modeled scenarios (cotton, potatoes, and tobacco) resulted in exceedences of the estuarine/marine invertebrate acute risk level of concern. All the remaining uses exceeded the restricted use level of concern. Similar uncertainty exists as to the validity of the exposure scenario for invertebrates as was just described for estuarine fish.

Chronic risk to marine/estuarine invertebrates is predicted. All of the modeled crop scenarios exceeded the chronic level of concern. The much shorter life cycle of invertebrates as compared to fish, increases the likelihood that only a brief exposure (a few day or even hours) of adults to disulfoton concentrations around the NOAEC is sufficient to negatively impact reproduction. The degree to which the freshwater microcosm is a predictor of safety for the estuarine invertebrates is highly uncertain. Only the mysid shrimp has been tested and it was acutely and

chronically less sensitive than freshwater Daphnia. Therefore, on the basis of this limited data, the chronic impact to estuarine invertebrates not only appears to be lower than for freshwater invertebrates, but is likely to be low.

Nontarget Plants: Currently, terrestrial and aquatic plant testing is not required for pesticides other than herbicides except on a case-by-case basis. Nontarget plant testing was not required for disulfoton, so the risk to plants could not be assessed at this time. There are phytotoxicity statements on the label, however, as well as some incident reports of possible plant damage from the use of disulfoton, so there is the potential for risk to nontarget plants.

Summary of Risk Assessment of North Carolina 24c for use in Christmas Tree Farms

Christmas tree farms and the adjacent areas -- forests and/or pasture -- provide excellent habitat for a great variety of wild life. The use of granular disulfoton suggests that there is acute risk to small birds and mammals. The North Carolina Christmas Tree community has submitted numerous testimonials emphasizing the ever increasing numbers and diversity of wild life. This includes game animals such as turkey rearing young amidst the Christmas trees, song birds, rodents and foxes. Although this information is intended to suggest there is little or no negative impact from not only disulfoton, but other pesticides or cultural practices as well, the Agency would prefer to receive documented surveys or research before making a final determination.

There were no detections of disulfoton, disulfoton sulfoxide, and disulfoton sulfone in the ground- water monitoring study conducted in North Carolina by the North Carolina Departments of Agriculture and Environment, Health, and Natural Resources. Seven Christmas tree, one wheat, and two tobacco growing areas were sampled for disulfoton. disulfoton residues. Limitations of the study include that sites were sampled only twice and the limits of detections were high (e.g., > 1.0 µg/L) for some of disulfoton analytes. Uncertainties associated with the study include whether two samples from eight wells are adequate to represent the ground-water concentrations of disulfoton residues, did DRASTIC correctly identify a site's vulnerability, and were the wells placed down-gradient of the use areas.

The use of Disulfoton 15 G in Christmas tree farms at this time cannot be modeled for potential surface water contamination. EFED assumes the estimated concentration for the North Carolina 24 (c) use pattern -- 2.75 lbs ai/ A unincorporated -- may be similar to the values for the single 4.0 lb ai/A incorporated application of granular disulfoton to tobacco. Based on this assumption there is acute risk to aquatic invertebrates and chronic risk to freshwater fish and aquatic invertebrates.

The North Carolina Christmas tree industry submitted two surveys of streams in the Westerns region. The surveys followed a protocol for looking at macro invertebrates to assess the impact of agricultural practices associated with Christmas tree farming. In summary, the two surveys suggests that when conservation measures associated with Christmas tree farming in the Western counties of North Carolina are implemented, there may be only slight, short term impact to aquatic macro invertebrates from disulfoton use. Aquatic macro invertebrates appear to have the capacity to recover from any impact that could be caused by disulfoton use on Christmas trees in Western North Carolina.

C. Mitigation

The use of disulfoton at single application rates of 1.0 lb ai/A and greater, and multiple application rates of 0.5 lb ai/A and greater, poses a high acute risk to birds, mammals, fish, and aquatic invertebrates, as well as to nontarget insects. EFED believes that amending label rates to the lowest efficacious rate as a maximum, as well as restricting the number of applications per year and lengthening the application interval, would reduce acute risk to terrestrial and aquatic organisms. Requiring in-furrow applications wherever feasible, and eliminating banded applications of granular disulfoton with narrow row spacing, would also reduce the risk to nontarget organisms, especially birds and mammals. Care must be taken, however, so that the likelihood of disulfoton or its degradates leaching to ground water is not increased by these application methods. Eliminating aerial applications of disulfoton and imposing buffer strips around aquatic habitats would reduce the risk to aquatic organisms. Risk to bees and other nontarget insects could be lowered by not applying disulfoton when the insects are likely to be visiting the area.

Qualitative comparative ecological risk assessment between present and proposed disulfoton uses.

Bayer has proposed the following changes to some use patterns assessed by the Agency that would reduce the ecological risk from Di-Syston 8E:

- *cancel aerial applications to cotton and wheat.
- *cancel foliar applications to cotton.

The table reflects additional changes proposed by Bayer.

Table 42. Comparison of present and proposed changes in 4 use patterns of Di-Syston 8E	
Present Use	Proposed Use
Rate/Number of Applications/Interval/Incorp. Depth/method ¹	Rate/Number of Applications /Interval/Incorp. Depth/method ¹
lb.ai/A/ #/ days/ inches	lb.ai/A/ #/ days/ inches
cotton 1.0/3/21/0/gs	cotton 1.0/1/-/0/gs
potatoes 4.0/2/14/2.5/gs	potatoes 3.0/1/-/2.5/gs
potatoes 1.0/3/14/0/af	potatoes 0.5/3/14-/0/af
wheat 0.75/2/30/0/gs	wheat 0.75/1/-/0/gs
¹ Method of application: f = foliar and s = soil; gs = ground spray, af = aerial spray-foliar	

Risk to Birds and Mammals

Canceling aerial application to wheat and cotton reduces significantly the potential for exposing

edge of field food items and vegetation. Canceling foliar applications to cotton reduces the opportunity for exposure, by reducing the food items that are directly sprayed. As the discussion below explains, field monitoring indicates that ground spray to soil reduces substantially the residues on food items from those residues predicted from the nomograph.

Potato aerial foliar at 0.5 lb ai/acre

Biological field testing (MRID 41359101) suggests that significant acute risk to mammals from foliar sprays is unlikely at a single application of 1 lb ai/acre or lower. Reducing the potato rate from 1 lb ai/acre 3 times, to 0.5 lb ai/acre 3 times, substantially lowers the acute risk to mammals.

Wheat, potato and cotton ground spray to soil

Field residue monitoring (MRID 41118901) indicates that residues on food items following ground applications to soil are significantly lower than would be expected from direct application to vegetation. Peak residues following the first of two treatments at 3 lb ai/acre (in furrow) ranged from 0.9 ppm (invertebrates and edge of field vegetation), to 26 ppm (potato foliage). The second treatment at 3 lb ai/acre side dressing (6-7 weeks later) resulted in peak residues of 1.8 (invertebrates), 44 ppm potato foliage, and 54 ppm (edge of field vegetation). The residues from these applications are not only lower than those estimated using the nomograph, but also lower than the field residues resulting from foliar applications. In the foliar residue monitoring study (3 aerial applications at 1.0 lb ai/acre) the peaks were: invertebrates (16 ppm) and vegetation (154 ppm). The proposed changes would greatly reduce exposure terrestrial species.

Table 43. Comparison of potential acute and chronic risk resulting from proposed changes in 4 use patterns of Di-Syston 8E for birds and mammals									
Present Use	Birds		Mammals		Proposed Use	Birds		Mammals	
Rate/Number of Apps/Interval/Incorp. Depth/method ¹	ac	ch	ac	ch	Rate/Number of Apps/Interval/Incorp. Depth/method ¹	ac	ch	ac	ch
lb.ai/A/ #/ days/ inches					lb.ai/A/ #/ days/ inches				
cotton 1.0/3/14/0/gs	E	Y	R	Y	cotton 1.0/1/-/0/gs	no	Y	E	Y
potatoes 4.0 /2/14/2.5/gs	R	Y	A	Y	potatoes 3.0/1/-/2.5/gs	E	Y	R	Y
potatoes 1.0/3/14/0/af	R	Y	A	Y	potatoes 0.5/3/14-/0/af	R	Y	R	Y
wheat 0.75/2/30/0/gs	E	Y	R	Y	wheat 0.75/1/-/0/gs	no	Y	E	Y
¹ Method of application: f = foliar and s = soil; g = ground and a = aerial Acute = ac; Chronic = ch Acute risk LOC is exceeded=A; Restricted use LOC is exceeded=R; Endangered Species LOC is exceeded=E; No acute LOC is exceeded= no; LOC for chronic risk is exceeded=Y; LOC for chronic risk is not exceeded=N.									

Risk to fish and aquatic invertebrates

The following table summarizes the results of modeling the proposed new uses. The EECs were reduced from the present registered use patterns:

Table 44 Tier II Upper Tenth Percentile EECs for Disulfoton Parent based on proposed new maximum label rates and management scenarios for cotton, potatoes, and spring wheat in farm pond. Estimated using PRZM3/EXAMS.								
Crop	Disulfoton Application	Concentration (µg/L) (1-in-10 annual yearly maximum value)						Mean of Annual Means (µg/L)
	Rate/Number of Apps/Interval/Incorp. Depth/method ¹							
	lb.ai/A/ #/ days/ inches	Peak	96-Hour Avg.	21-Day Avg.	60-Day Avg.	90-Day Avg.	Annual Avg.	
Cotton	1.00/1/-/0/gs	10.31	9.38	6.83	3.54	2.42	0.62	0.23
Potatoes	3.00/1/-/2.5/gs	2.42	2.18	1.67	0.84	0.57	0.15	0.12
Potatoes	0.5/1/-/0/af	7.51	6.62	5.20	3.45	2.42	0.62	0.57
Spr.Wheat	0.75/1/-/0/gs	1.02	0.91	0.67	0.41	0.28	0.08	0.05

¹ Method of application: f = foliar and s = soil; g = ground and a = aerial

The following tables reflect a qualitative comparative risk assessment for aquatic and estuarine organisms.

Table 45. Comparison of potential acute and chronic risk resulting from proposed changes in 4 use patterns of Di-Syston 8E for freshwater fish and invertebrates									
Present Use	Fish		Invertebrates		Proposed Use	Fish		Invertebrates	
Rate/Number of Apps/Interval/Incorp. Depth/method ¹	a	ch	ac	ch	Rate/Number of Apps/Interval/Incorp. Depth/method ¹	ac	ch	ac	ch
lb.ai/A/ #/ days/ inches					lb.ai/A/ #/ days/ inches				
cotton 1.0/3/14/0/gs	R	Y	A	Y	cotton 1.0/1/-/0/gs	R	N	A	Y
potatoes 4.0/2/14/2.5/gs	R	Y	A	Y	potatoes 3.0/1/-/2.5/gs	E	N	A	Y
potatoes 1.0/3/14/0/af	R	Y	A	Y	potatoes 0.5/3/14-/0/af	R	N	A	Y
wheat 0.75/2/30/0/gs	R	N	A	Y	wheat 0.75/1/-/0/gs	no	N	R	Y
¹ Method of application: f = foliar and s = soil; g = ground and a = aerial Acute = ac; Chronic = ch Acute risk LOC is exceeded=A; Restricted use LOC is exceeded=R; Endangered Species LOC is exceeded=E; No acute LOC is exceeded= no; LOC for chronic risk is exceeded=Y; LOC for chronic risk is not exceeded=N.									

Table 46. Comparison of potential acute and chronic risk resulting from proposed changes in 4 use patterns of Di-Syston 8E for estuarine fish and invertebrates									
Present Use	Fish		Invertebrates		Proposed Use	Fish		Invertebrates	
Rate/Number of Apps/Interval/Incorp. Depth/method ¹	ac	ch	ac	ch	Rate/Number of Apps/Interval/Incorp. Depth/method ¹	ac	ch	ac	ch
lb.ai/A/ #/ days/ inches					lb.ai/A/ #/ days/ inches				
cotton 1.0/3/14/0/gs	no	Y	A	Y	cotton 1.0/1/-/0/gs	no	Y	A	Y
potatoes 4.0/2/14/2.5/gs	no	Y	R	Y	potatoes 3.0/1/-/2.5/gs	no	N	R	N
potatoes 1.0/3/14/0/af	no	Y	A	Y	potatoes 0.5/3/14-/0/af	no	Y	A	Y
wheat 0.75/2/30/0/gs	no	Y	A	Y	wheat 0.75/1/-/0/gs	no	N	E	N
¹ Method of application: f = foliar and s = soil; g = ground and a = aerial Acute = ac; Chronic = ch Acute risk LOC is exceeded=A; Restricted use LOC is exceeded=R; Endangered Species LOC is exceeded=E; No acute LOC is exceeded= no; LOC for chronic risk is exceeded=Y; LOC for chronic risk is not exceeded=N.									

Summary

EFED supports the proposed use modifications, and concurs that generally they reduce risk to nontarget organisms to varying degrees. Although there remains the concern for hypersensitive birds and mammals, the acute risk to most birds and mammals is reduced substantially. The greatest risk reduction to fish and aquatic invertebrate are soil applications to potatoes and wheat. There appears to be little changes in acute risk to aquatic organisms from the proposed modifications to cotton and potatoes (aerial application). Chronic risk to terrestrial and aquatic organisms are likely to be reduced; but with less certainty, because the duration of exposure required to produce adverse chronic effects in the field are not available.

7. References

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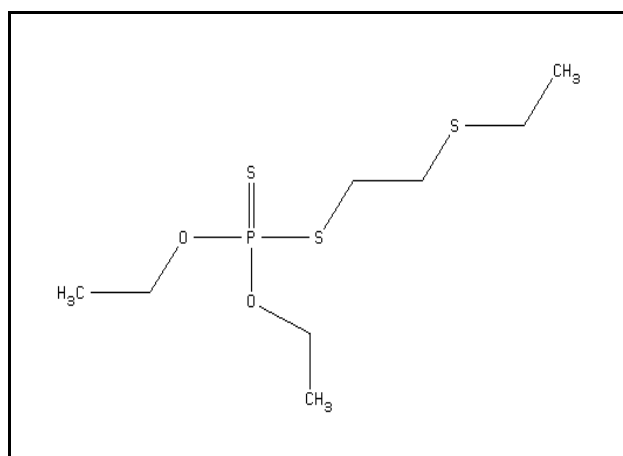
APPENDIX I: USE OF DISULFOTON (LB. AI/YR) BY CROP AND BY STATE

Crop	Percent of market	lb ai/yr (Doane's Agriculture Service data)	lb ai/yr (estimate provided by BEAD, based on market information)
Cotton	61	428,000	420,000-840,000
Wheat	16	123,000	180,000-354,000
Barley	7	49,000	29,000-77,000
Potatoes	7	50,000	120,000-195,000
Peanuts	5	27,000	47,000-106,000
Cole crops	2	14,000	no information
Corn	1	4,000	36,000-73,000
Tobacco	1	4,000	64,000-128,000

State	Percent of market	lb ai/yr (based on total ai/yr of 1,700,000 lb)
California	16	272,000
Louisiana	11	187,000
Kentucky	10	170,000
Missouri	8	136,000
Arkansas	8	136,000
Texas	7	119,000
Alabama	7	119,000
Virginia	6	102,000
North Carolina	5	85,000
Maine	4	68,000
Mississippi	4	68,000
Utah	4	68,000
Georgia	3	51,000
Michigan	2	34,000
Ohio	2	34,000

Arizona	1	17,000
New Mexico	1	17,000

APPENDIX II: Chemical Structure of Disulfoton



APPENDIX III

The monitoring data obtained from STORET on October 16, 1997 are summarized in Table 1. The majority of samples had low levels ($<16 \mu\text{g/L}$) of disulfoton residues. However, there were indications of some high concentrations (may be a reflection of how the data were reported) as the disulfoton concentrations in the monitoring were not always known. This is because the detection limit was not adequate (extremely high) or specified, and/or the limit of quantification was not stated or extremely high. Disulfoton concentrations were simply given as less than a value. Therefore, considerable uncertainty exists with respect to the monitoring data (especially the STORET data).

Limitations in Monitoring

Monitoring data is limited by the lack of correlation between sampling date and the use patterns of the pesticide within the study's drainage basin. Additionally, the sample locations were not associated with actual drinking water intakes for surface water nor were the monitored wells associated with known ground water drinking water sources. Also, due to many different analytical detection limits, no specified detection limits, or extremely high detection limits, a detailed interpretation of the monitoring data is not always possible.

Table 1. Summary of disulfoton detections in STORET.			
Type of Water Body	# of Samples	Analytical Method	Disulfoton Concentration ¹ (range µg/L)
Stream	1940	39010/39011 ²	0.00-16.00
“	253	81888 ³	0.00-100.00
“	39	82617 ⁴	0.05-1.00
“	5164	82677 ⁵	0.00-0.21
Lakes	270	39011	0.01-0.10
“	2	81888	0.05-0.14
“	20	82617	1.00-1.00
“	52	82677	0.00-0.10
Springs	24	39011	0.01-0.10
“	15	81888	0.05-100.00
“	134	82677	0.008-0.060
Reservoirs	2	81888	0.10-0.20
Estuary	4	39011	0.01
“	1	82677	0.02
Canals	2	39011	0.5
“	215	81888	0.03-0.3
Wells	383	39010	1.00-100.00
“	951	39011	0.01-1.00
“	3108	81888	0.00-250.00
“	44	82617	0.03-1.00
“	2559	82677	0.00-0.14

¹ Value reported as “known to be less than reported”.

² 39010/39011 Flame Photometer Whole Water: disulfoton/Di syston

³ 81888 Disulfoton Whole Water

⁴ 82617 Disulfoton Total Recoverable whole water

⁵ 82677 Disulfoton “filtered 0.07 µm” Total Recoverable whole water

Appendix IV

Environmental Fate and Chemistry Study Identification

Blumhorst, R.B., and P.Y. Yen. Aerobic Soil Metabolism of [Ethylene-1-¹⁴C Disulfoton.] Bayer Report 106944, Study No. D1042103. Unpublished study performed by EPL Bio-Analytical Services., Kansas City, Missouri.

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Graney, R.L., 1989. MRID-43042501. Supplemental submission containing raw data for: uptake, depuration and bioconcentration of ¹⁴C Di-Syston to bluegill sunfish (*Lepomis macrochirus*). Mobay Project ID:95078-1. Unpublished study performed by Analytical Biochemistry Lab., Columbia, MO and submitted by Miles, Inc., Kansas City, MO.

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APPENDIX V:

Chemical No: 032501

ENVIRONMENTAL FATE
DATA REQUIREMENTS FOR
Disulfoton



Guideline	Use Pattern	Does EPA Have Data to Satisfy the Guideline Req.?	MRID No.	More Data Required?
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§158.290 ENVIRONMENTAL FATE**Degradation Studies-Lab:**

161-1	Hydrolysis	1,2,3	Yes	00143405	No
161-2	Photodegradation In Water	1,2,3	Yes	40471102	No
161-3	Photodegradation On Soil	1,2,3	Yes	40471103	No

Metabolism Studies-Lab:

162-1	Aerobic Soil	1,2,3	Yes	43800101,40042201,41585101	No
162-2	Anaerobic Soil	1,2,3	No		No
162-3	Anaerobic Aquatic	1,2,3	No	(43042503 ²)	Yes
162-4	Aerobic Aquatic	1,2,3	No		No

Mobility Studies:

163-1	Leaching- Adsorption/Desorp.	1,2,3	Yes	44373103,00145469,43042500,00145470	No
163-2	Volatility (Lab)	1,2,3	Yes	42585802	No

Dissipation Studies-Field:

164-1	Soil	1,2,3	Yes	43042502	No
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Accumulation Studies:

165-4	In Fish	1,2,3	Partially	43042501,43060101,40471106,40471107	No
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Ground Water Monitoring Studies:

166-1	Small-Scale Prospective
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§158.440 Spray Drift:

201-1	Droplet Size Spectrum
202-1	Drift Field Evaluation

FOOTNOTES:

Appendix VI: Ecological Effects Data Table

Generic Data Requirements for Disulfoton (parent compound) as of 02/02/98

Data Requirement	Composition	Does EPA Have Data to Satisfy Data Req?	MRID Citation	Were Data Submitted Under FIFRA 3(c)(2)(B)?
158.490 Wildlife and Aquatic Organisms				
<u>AVIAN AND MAMMALIAN TESTING</u>				
71-1 Avian oral LD ₅₀	TGAI	Yes	25525,00095655, GS0102700,05008363,425858-03	No
71-2 Avian dietary LC ₅₀	TGAI	Yes	0094233,00058746,120480	No
71-3 Wild Mammal Toxicity	TGAI	No		Yes
71-4 Avian Reproduction	TGAI	Yes	43032501, 43032502	No
71-5 Simulated and actual field testing-mammals and birds	TEP	Partially	00095658,00095657	No
<u>AQUATIC ORGANISM TESTING</u>				
72-1 Freshwater fish LC ₅₀				
a. Warmwater	TGAI	Yes	40098001,00068268,00003503	No
b. Warmwater	TEP	Yes	229299, 00068268 ¹	No
c. Coldwater	TGAI	Yes	40098001,00068268,00003503	No
d. Coldwater	TEP	Yes	00068268 ²	No
72-2 Freshwater Invertebrate EC ₅₀				
a.	TGAI	Yes	00003503,00143401	No
b.	TEP	No		No
c.	Degradate	Yes	425851-09,42585-12	No
72-3 Marine/Estuarine Acute LC ₅₀				
a. fish	TGAI	Yes	400716-01	No
b. mollusk	TGAI	Yes	400716-02	No
c. shrimp	TGAI	Yes	400716-03	No
d. fish	TEP	No		No
e. mollusk	TEP	No		No
f. shrimp	TEP	No		No

¹Submitted study was classified as supplemental and must be repeated in order to fulfill Guidelines requirements

72-4a Fish early life stage	TGAI	Yes (freshwater) (marine-estuarine) 426290-01	419358-01	No Yes No
b Aquatic invert. life-cycle	TGAI (freshwater)	Yes	419358-02 419358-01 419358-02	No
	marine-estuarine)	Yes	436109-01	No
72-5 Fish Life Cycle	TGAI (marine-estuarine)	Yes	43960501	No
72-6 Aquatic organism accumulation	TGAI	Yes (See Environmental fate guideline 165-1)	No	No
72-7 Simulated or actual field testing - aquatic organisms	TEP	Yes		
<u>158.150 PLANT PROTECTION - Nontarget Area Phytotoxicity</u>				
TIER I				
122-1 Seed seedling emergence	TGAI	No		Yes
122-1 Vegetative vigor	TGAI	No		Yes
122-2 Aquatic plant growth	TGAI	No		No
TIER II				
123-1 Seed germ./seedling emergence	TGAI	No		No
123-1 Vegetative vigor	TGAI	No		No
123-2 Aquatic plant growth	TGAI	No		No
TIER III				
124-1: Terrestrial plant field testing	TEP	No		No
124-2: Aquatic plant field testing	TEP	No		No
<u>158.590 NONTARGET INSECT TESTING - POLLINATORS</u>				
141-1 Honeybee acute contact toxicity	TGA	Yes	00066220,05001991,05004151	No
141-2 Honeybee toxicity of residues	TEP	Yes	0163423	No
141-5 Field testing for pollinators	TEP	No		No

Appendix VII. Summary of Maximum Percent Crop Areas (without Land Use coverage)

CROP	MAXIMUM PERCENT CROP AREA (as a decimal)	HYDROLOGIC UNIT CODE (8-DIGIT HUC)	STATE
Wheat	0.56	09010001	N. Dakota
Cotton	0.20	08030207	Mississippi
Soybeans-Cotton	0.49 (0.31 soybeans, 0.18 cotton)	08020204	Missouri
All Agricultural Land	0.87	10230002	Iowa

Note that there is an entry for ‘All Agricultural Land’ in Appendix 2, Table 1. This is a default value to use for crops for which no specific PCA is available. It represents the largest amount of land in agricultural production in any 8-digit hydrologic unit code (HUC) watershed in the continental United States.

Appendix VIII. PRZM input parameters where modifications were necessary for the Index Reservoir (IR) Scenario

PRZM variable	Farm Pond Value	IR Scenario	Definition
AFIELD	10 ha	172.8 ha	area of plot or field
HL	374 m scenario specific	464 ¹ m or 600m	Hydraulic length
DRFT	0.01 ground 0.05 aerial	0.064 ground 0.16 aerial	Spray drift

¹ This value changed between versions Guidance document and modeling of data during the development of the Guidance document. The PRZM Input file and the EXAMS environment (index reservoir) were matched.

As noted above in above table, the value for the variable HL changed between Guidance document versions and modeling. The HL (hydraulic length) value changed from 464 m to 600. The PRZM input files were in agreement with whichever environment or index reservoir that was used.